P6

REPORT

ACCESSION NO. 125

CALCIUM HYDROXIDE

CAS REG. NO. 001305620

AND

CALCIUM OXIDE

CAS REG. NO. 001305788

GRAS Review Branch (BF-335)
Bureau of Foods
Food and Drug Administration
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Submitted to Att: Mr. Alan Spiher
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Date March 30, 1973

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CALCIUM OXIDE

Summary - Toxicological Information

Acute, short, and long term data were not present in the available literature.

Calcium oxide when mixed with maize, will cause the vitamins present therein (nicotinic acid, riboflavin and thiamine) to degenerate. This nutritive deficiency will manifest itself in the form of growth rate depression, if the treated maize is subsequently fed to rats (33).

A total of 10,230,040 pounds of calcium oxide was used in the United States in 1970 as reported in an NAS/FEMA study.

CALCIUM OXIDE

Chemical Information

I. Nomenclature (74)

A. Common Name

Lime

Quick Lime

Calx

B. Chemical Name

Calcium Oxide

C. Trade Name

(none)

D. Chemical Abstracts Unique Registry Number

001305788

II. Empirical Formula (74)

CaO

III. Structural Formula

CaO

IV. Molecular Weight (74)

56.08

V. Specifications

A. Chemical (93: p. 194)

Ca - 71.47%

O - 28.53%

B. Food Grade (74)

Assay: not less than 95% of CaO after ignition.

Limits of Impurities

Acid-insoluble substances: not more than 1%.

Alkalies or magnesium: not more than 3.6%.

Arsenic (as As): not more than 3 parts per million (0.0003%).

Fluoride: not more than 50 parts per million (0.005%).

Heavy metals (as Pb): not more than 40 parts per million (0.004%).

Lead: not more than 10 parts per million (0.001%).

Loss on ignition: not more than 10%.

C. Offical Compendia

Food Chemical Codex - First Edition. p. 124.

VI. Description

A. General Characteristics (74)

Hard, white or grayish white masses or granules, or a white to grayish white powder. It is odorless.

B. Physical Characteristics (93)

Sometimes has a yellowish or brownish tint, due to iron.

Readily absorbs CO_2 and H_2O from air, becoming airslaked.

Soluble in water, forming $Ca(OH)_2$ and generating a large quantity of heat.

Soluble in acids, glycerol, sugar solution.

Insoluble in alcohol.

Melting point. 2572°

Boiling Point. 2850°

C. Stability in Containers (74)

Store in tight containers.

VII. Analytical Methods

Flame photometric determination of lime in food stuffs and soils. (55).

Identification of CaO among other metal oxides by infrared absorption. (23).

VIII. Occurrences and levels found in:

A. Plants

(none)

B. Animals

(none)

C. Synthetics

(none)

D. Natural Inorganic sources

Ubiquitous

CALCIUM OXIDE

Biological Data

I. Acute Toxicity

(none)

II. Short Term Studies

(none)

III. Long Term Studies

(none)

IV. Special Studies

Rats fed maize treated with lime manifested depressed growth rates as compared to controls. This effect is due to the degenerative action of lime on nicotinic acid, riboflavin, and thiamine (33).

CALCIUM OXIDE

Biochemical Aspects

I. Breakdown

(none)

II. Absorption - Distribution

(none)

III. Metabolism and Excretion

(none)

IV. Effects on Enzymes and Other Biochemical Parameters

(none)

V. Drug Interaction

(none)

VI. Consumer Exposure Information

(none)

CALCIUM HYDROXIDE

Summary - Toxicological Information

The acute oral toxicity (LD_{50}) for calcium hydroxide in rats is 7.34 (4.83 - 11.14) g/kg (103); data on short and long term studies are lacking.

When taken orally by humans calcium hydroxide was found to inhibit the growth of gram positive cocci and of lactobacteria involved in various cariogenic activities (61).

Cellular atypia have been induced in hamster cheek pouches treated with 250 mg of calcium hydroxide per day three times a week for up to 121 weeks (70), and studies with its effect on the myelin sheath of rabbit muscle indicate that this material is an excellent nerve sclerosing agent (87).

Calcium hydroxide is a potential environmental pollutant (101) especially in rivers and streams where it can be fatal to fish (trout for example) at relatively low concentrations.

A total of 853,125 pounds of calcium hydroxide was used in the United States in 1970 as reported in an NAS/FEMA study.

CALCIUM HYDROXIDE

Chemical Information

I. Nomenclature (74)

A. Common Name

Slaked Lime

B. Chemical Name

Calcium Hydroxide

C. Trade Name

(none)

D. Chemical Abstracts Unique Number

001305620

II. Empirical Formula (74)

$Ca(OH)_2$

III. Structural Formula

$Ca(OH)_2$

IV. Molecular Weight (74)

74.09

V. Specifications

A. Chemical (93: p. 193)

Ca - 54.09%
H - 2.72%
O - 43.10%

B. Food Grade (74)

Assay: not less than 95% of $Ca(OH)_2$

Limits of Impurities

Acid-Insoluble substances: not more than 1%.

Arsenic (as As): not more than 3 parts per million (0.0003%).

Fluoride: not more than 50 parts per million (0.005%).

Heavy metals (as Pb): not more than 40 parts per million (0.004%).

Lead: not more than 10 parts per million (0.001%).

Magnesium and alkali salts: not more than 4.8%.

C. Official Compendia

Food Chemical Codex - First Edition p. 117.

VI. Description

A. General Characteristics (93)

Crystals or soft, odorless, granules or powder. Slightly bitter, alkaline taste.

B. Physical Characteristics (93)

Readily absorbs CO_2 from air forming $CaCO_3$

When ignited it loses H_2O leaving CaO.

Slightly soluble in water.

Soluble in glycerol, sugar or NH_4Cl solutions.

Soluble in acids with evolution of much heat.

pH of aqueous solution saturated at 25°: 12.4

Insoluble in alcohol.

C. Stability in Containers

Store in tight containers. (74)

VII. Analytical Methods

Titrimetric/colorimetric determination. (74)

VIII. Occurrences and Levels found in:

A. Plants

(none)

B. Animal

(none)

C. Synthetics

(none)

D. Natural Inorganic Sources

Ubiquitous

CALCIUM HYDROXIDE

Biological Data

I. Acute Toxicity

Animal	Route	Material	LD_{50} mg/kg	Ref.
Rat	Oral	$Ca(OH)_2$	7,340 (4,830-11,140)	103

II. Short Term Studies

(none)

III. Long Term Studies

(none)

IV. Special Studies

Studies conducted in 11 humans who were treated with $Ca(OH)_2$ orally, revealed a growth inhibition of gram-positive cocci and lacto-bacteria which are involved with certain cariogenic activities and depressed the hemolytic properties of isolated strains (61).

Hamster cheek pouches treated repeatedly (250 mg/day 3 times a week) with $Ca(OH)_2$ for 81-121 weeks resulted in an incidence in 3 out of 6 animals of cellular atypia in the cheek epithelial cells which were suggestive of a pre-neoplastic condition (70).

When 0.25 ml of $Ca(OH)_2$ at pH 12.9 was injected under the myelin sheath of rabbit muscle, severe focal coagulation necrosis affecting the axis cylinders, myelin sheath and Schwann cells occurred. This nerve damage cleared somewhat after 4 weeks (87). It would appear that $Ca(OH)_2$ is an effective nerve sclerosing agent.

$Ca(OH)_2$ is also a potential environmental pollutant; trout exposed to concentrations of 100, 200, 250 and 2000 ppm died in 7 days. Concentrations of 50, 100 and 1000 ppm, however, were not toxic when the water hardness was changed (101).

CALCIUM HYDROXIDE

Biochemical Aspects

I. Breakdown

(none)

II. Absorption - Distribution

(none)

III. Metabolism and Excretion

(none)

IV. Effects on Enzymes and Other Biochemical Parameters

(none)

V. Drug Interaction

(none)

VI. Consumer Exposure Information

(none)

CALCIUM OXIDE

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Spectrochimica Acta, 1964, Vol. 20, pp. 799 to 808. Pergamon Press Ltd. Printed in Northern Ireland

Infrared absorption study of metal oxides in the low frequency region (700–240 cm^{-1})

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(*Received 5 September* 1963)

Abstract—The characteristic frequencies of oxides of 52 metals have been studied in the region 700–240 cm^{-1}. Data for oxides of metals of different valence states and the frequencies of polymorphic forms of several oxides are presented. A particle size of 10 μ or smaller was found to give the best representative spectrum.

INTRODUCTION

IN THE past several years the majority of metal oxide compounds have become important for various reasons. Two of the more important of these are their high temperature stability for use as refractory bodies, and their optical properties for use as infrared lenses. The metal oxides have not been extensively studied in the infrared region, and an investigation of the absorption characteristics of these materials should therefore be of interest.

A review article on inorganic materials by LAWSON [1] revealed very little information on oxides, and the papers by MILLER [2, 3] and co-workers deal primarily with the spectra of a large number of inorganic salts. Some Raman data have been presented on diverse oxides [4] consisting of the salts of molybdates, tungstates, arsenates and chromates. The earlier infrared studies in the rock salt region deal primarily with individual compounds, with papers on magnesia [5], titania [6] and yttria [7]. Some spectra of oxides have extended into the low frequency region; and there are papers on oxides of beryllium [8], silicon [9], aluminum [10], boron [11], arsenic [12, 13], tellurium [14], titanium and

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vanadium [15]. Several papers by Parodi [16, 17, 18] report frequencies on a number of divalent metal oxides.

In a fundamental study of the properties of refractory materials it was found that the infrared spectrum, in the region between 700 and 240 cm^{-1}, was more informative for these oxides than the conventional rock salt region. For this reason the study of the absorption characteristics of a large number of metal oxides was undertaken.

Experimental

The instrument used was the Perkin–Elmer Model 102, a spectrophotometer designed and constructed specifically for our Laboratory. The instrument has a prism-grating double beam monochromator and records linearly in wavenumbers. In the automatic mode the spectrophotometer is capable of recording spectra from 4000–240 wavenumbers. For the conditions under which the spectra reported in this paper were obtained, a KBr and CsI foreprism were used in combination with a 30 μ blazed grating to cover the region 700–240 cm^{-1}, with a spectral slit width of 4 cm^{-1}.

The majority of the samples were commercial chemicals of C.P. grade while the rare-earth oxides were of spectrographic purity. Several of the polymorphic forms were prepared in our laboratory by standard procedures. The crystal form of each oxide was checked by X-ray diffraction.

All of the spectra were obtained as Nujol mulls. Nujol has only a weak absorption band at 720 cm^{-1} and proves to be an ideal mulling agent for this region. Compounds that gave indications of having a band under the 720 Nujol band were re-run as KBr disks. The Nujol mull samples were dispersed between CsI plates. The instrument was flushed with dry air until satisfactory energy checks were obtained at 250 cm^{-1}.

Results and Discussion

A discussion of each infrared spectrum of the metal oxides would exceed the space limitations of this paper. Only a general discussion concerning particle size, rare-earth oxides, polymorphism and a few of the individual compounds will be presented.

Table 1 is an alphabetical listing of all the compounds that have been studied. The second column shows the compound or compounds that result from different valence states and polymorphic forms. The third column shows the positions of the bands. An asterisk after the compound formula means that the bands in the spectrum for that particular compound are poorly defined. The relative intensities of the characteristic bands are included in this Table; however, they refer only to bands within each individual spectrum. This information has no meaning, from one curve to another, when dealing with these solid inorganic substances in Nujol mulls. The band shapes are noted where they are broad or occur as a shoulder on other bands. Where the crystal structure of a compound has not been noted the common stable form was used.

[15] S. M. Ariya and M. V. Golomolzina, *Soviet Phys.—Solid State* **4**, 2142 (1963).
[16] M. Parodi, *Compt. rend.* **204**, 1111 (1937).
[17] M. Parodi, *Compt. rend.* **204**, 1636 (1937).
[18] M. Parodi, *Compt. rend.* **205**, 906 (1937).

Table 1. Characteristic frequencies of metal oxide infrared absorption bands

Metal	Formula	Region (cm^{-1})
Aluminum	χAl_2O_3	575 s, 432 s, 375 sh
Antimony	Sb_2O_3 (cubic)	740 s, 685 sh, 590 m, 550 sh, 482 m, 383 s, 345 w, 322 w, 265 s
Arsenic	As_2O_3 cubic	500 sh, 475 s, 355 sh, 340 s
Barium	BaO	503 sh, 483 s, 305 sh, 283 m, 255 m
	BaO_2	(No bands 700–250)
Beryllium	BeO	(No bands 700–250)
Bismuth	αBi_2O_3	645 w, 505 s, 345 s
Boron	B_2O_3	765 sb, 638 m, 543 m
Cadmium	CdO	(No bands 700–250)
Calcium	CaO	400 sb, 290 m
Cerium	CeO_2	525 sh, 425 s vb
Chromium	CrO_3	(No bands 700–250)
	Cr_2O_3	625 s, 555 s, 435 w, 407 w
Cobalt	Co_3O_4	655 s, 635 sh, 562 s, 460 b sh, 350 w
Copper	CuO	610 m, 500 s, 410 m
	Cu_2O	615
Dysprosium	Dy_2O_3 (cubic)	550 s, 408 s vb, 320 m, 307 w, 284 w, 273 w
Erbium	Er_2O_3 (cubic)	563 s, 465 b sh, 367 s, 325 m, 285 m
Europium	Eu_2O_3 (monoclinic)	630 w, 510 sh, 365 s vb
Gadolinium	Gd_2O_3 (cubic)	535 s, 465 b sh, 350 s, 310 m, 297 w, 270 m
Gallium	βGa_2O_3	663 s, 450 sb, 364 m, 305 mb
Germanium	GeO_2 (hexagonal)	585 s, 550 s, 512 s, 332 s, 255 m
Gold	Au_2O_3	607
Hafnium	HfO_2 (monoclinic)	755 m, 645 m, 530 s, 450 sh, 425 s, 375 w, 350 sh
Holmium	Ho_2O_3 (cubic)	559 s, 470 b sh, 370 s, 325m, 310 sh 285 m
Indium	In_2O_3	(No bands 700–250)
Iron	αFe_2O_3	560 sb, 468 s, 370 sh, 325 s
	γFe_2O_3*	555, 468, 336
	Fe_3O_4	570 sb, 385 mb
Lanthanum	La_2O_3	644 w, 415 sb
Lead	PbO (orthorhombic)	500 m, 377 s, 300 s
	PbO_2 (tetragonal)	(No bands 700–250)
	Pb_3O_4	650 w, 525 s, 445 s, 380 s, 320 m
Lutetium	Lu_2O_3	570 s, 485 b sh, 382 s, 337 m, 297 m
Magnesium	MgO	445 vb
Manganese	MnO_2 (tetragonal)	615 s vb, 400 m, 335 w
	Mn_3O_4*	600, 475 393
Mercury	HgO (yellow)	588 s, 480 s
	HgO (red)	573 s, 475 s
Molybdenum	MoO_3*	660, 375, 300
Neodymium	Nd_2O_3*	655
Nickel	NiO	650 w, 465 s vb
Niobium	αNb_2O_5*	478, 295
	δNb_2O_5*	575, 455 sh, 357
Praseodymium	Pr_6O_{11}	655 m, 500 sh, 350 s vb
Ruthenium	RuO_2	(No bands 700–250)
Samarium	Sm_2O_3 (monoclinic)	640 w, 530 sh, 370 s vb
Scandium	Sc_2O_3	625 s, 525 sh, 425 s, 382 s, 382 m, 365 w, 343 w
Silicon	SiO_2 (dehydrated silica-gel)	460 b
	SiO_2 (α quartz)	775 m, 693 w, 510 sh, 450 s, 385 sh, 362 s, 257 m
Silver	Ag_2O	645 m, 540 s
Strontium	SrO_2	590 sb, 525 sh
Tantalum	αTa_2O_5	612 s vb, 450 b sh, 300 m
	βTa_2O_5*	575, 455 sh, 315
Thorium	ThO_2	645 sh, 310 s vb
Thulium	Tm_2O_3	565 s, 485 sh, 380 s, 335 w, 295 w
Tin	SnO* (tetragonal)	650, 480
	SnO_2	670 m, 610 sh, 312 s
Titanium	TiO_2 (anatase)	700 s vb, 525 s vb, 347 m
	TiO_2 (rutile)	695 sh, 608 sb, 423 w, 352 w
	Ti_2O_3*	650 (No bands 600–250)
Tungsten	WO_2	(No bands 700–250)
	WO_3*	355, 315
Vanadium	V_2O_5	595 s vb, 395 w, 288 w
Ytterbium	Yb_2O_3	569 s, 400 sb, 330 m, 322 sh, 296 m
Yttrium	Y_2O_3 (cubic)	561 s, 423 sb, 333 m, 325 sh, 300 m
Zinc	ZnO	450 vb
Zirconium	ZrO_2 (monoclinic)	745 m, 620 sh, 530 sb, 450 w, 420 w, 375 w, 360 sh
	ZrO_2 (cubic CaO stabilized)	490 vb

* Bands are poorly defined. s = high intensity, m = medium intensity, w = low intensity, b = broad, v = very, sh = shoulder (the intensity values should be compared only with bands in the same spectrum).

Sample preparation

It became apparent after recording the spectra of several of the metal oxides that a specific procedure would be necessary in order to obtain reproducible spectra from each sample. The ordinary mulling techniques were made more difficult by the varying hardness of the metal oxides. Difficulties of this nature have been encountered previously and various techniques have been studied [5, 19] in order to obtain representative and reproducible spectra. A review article by Duyckaerts [20] shows the effects that can occur in an infrared spectrum of solid substances. In this study 200 mg of each compound was ground dry in a mortar and pestle for approximately one minute with an additional one minute dry grind in a vial in a Wig–L–Bug vibrator. A plastic vial was normally used but requires caution with respect to contamination [21]. However, with 200 mg of oxide sample the concentration of the plastic in the sample remained small and did not prove to be a problem when recorded as a Nujol mull. Approximately 50 mg of the preground sample was then mulled with Nujol. In some cases the thoroughly ground samples were also pressed into KBr disks for cross-checking purposes. In general the bands in the pellet spectra were less asymmetric than in the Nujol mull spectra. This was probably due to a decrease in scatter from the smaller amount of sample in the KBr matrix. The sample concentration ranged between 0·3 and 0·6 per cent for the compounds studied, which is small for this region of the infrared when compared to the 1 per cent normally used for organic materials.

Characteristics of the spectra

The instrument is capable of recording frequencies with an accuracy of $\pm 0{\cdot}5$ cm^{-1}. The band positions reported in this paper should be accurate to within $\pm 2{\cdot}0$ cm^{-1}. For very broad bands the error in determining the peak frequency would sometimes be greater than this value.

The study of inorganic compounds in the low frequency region of the infrared can be complex. Some theory about the spectra resulting from vibrational transitions in organic solids can be obtained from a comprehensive review by Mitra [22]. For the most part these data deal only with the practical applications of the low frequency spectra and no attempt is made to assign specific vibrational modes.

The effect of particle size on the infrared spectrum can be seen in Figs. 1 and 2. Figure 1 shows the spectrum of red mercuric oxide after various amounts of grinding. The initial curve represents the compound after it was ground a very short time with a mortar and pestle. The resulting spectrum has a very broad band with two possible maxima at 550 and 450 cm^{-1}. The sample was then ground in a vial using a Wig–L–Bug vibrator and curves A–C represent increased grinding periods. The final spectrum (curve C, 90 sec) shows two distinct peaks with maxima at 573 and 475 cm^{-1} indicating the two bands have shifted to a higher frequency by about 25 cm^{-1}. In contrast to this the yellow mercuric oxide gives two well defined peaks at 590 and 488 with only a very short grinding period. Using

[19] W. M. Tuddenham and R. J. Lyon, *Anal. Chem.* **32,** 1630 (1960).
[20] G. Duyckaerts, *Analyst* **84,** 201 (1959).
[21] N. T. McDevitt and W. L. Baun, *Appl. Spectrosc.* **14,** 135 (1960).
[22] S. S. Mitra, *Solid State Phys.* **13,** 1 (1962).

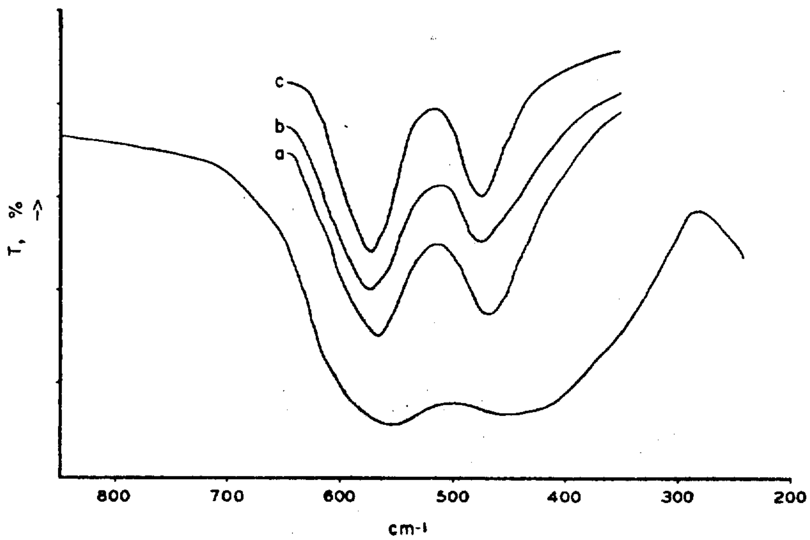

Fig. 1. Red mercuric oxide spectrum. Initial spectrum very short grinding period; a—20 seconds dry grinding with Wig–L–Bug vibrator; b—45 seconds; c—90 seconds.

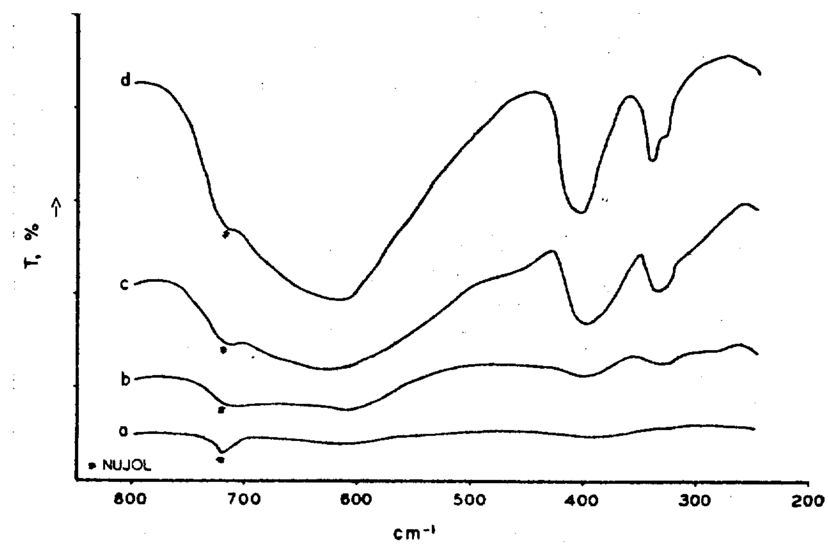

Fig. 2. MnO_2 spectrum. a—no grinding; b—one minute dry grinding with a mortar and pestle; c—one minute mortar and pestle plus one minute in a steel vial with a vibrator; d—one minute mortar and pestle plus two minutes in a steel vial with a vibrator.

the same procedure as described above for the red compound, the final spectrum of the yellow mercuric oxide had the same band shape as the initial curve and the peak frequencies are almost constant at 588 and 430 cm^{-1}. This is probably the most dramatic difference that will be seen among the metal oxides. All the data for these compounds show they have the same chemical composition, the same structure, and the most recent X-ray powder data by the National Bureau of Standards reports that the red oxide gives the same diffraction pattern as the yellow compound. Photomicrographs of the two materials as received show the yellow mercuric oxide average particle size to be about 5 μ, while the red mercuric oxide average particle size is nearly 20 μ. Therefore, the particle size of the yellow compound is approximately $\frac{1}{5}$ the wavelength of its absorption bands while the particle size of the red oxide is just about equal to its maximum absorption wavelength. It appears that this is the reason for the difference in their infrared spectra. The increase in frequency of the red oxide absorption bands on grinding could be attributed to particle size or possibly to a lattice strain set up in the molecule through

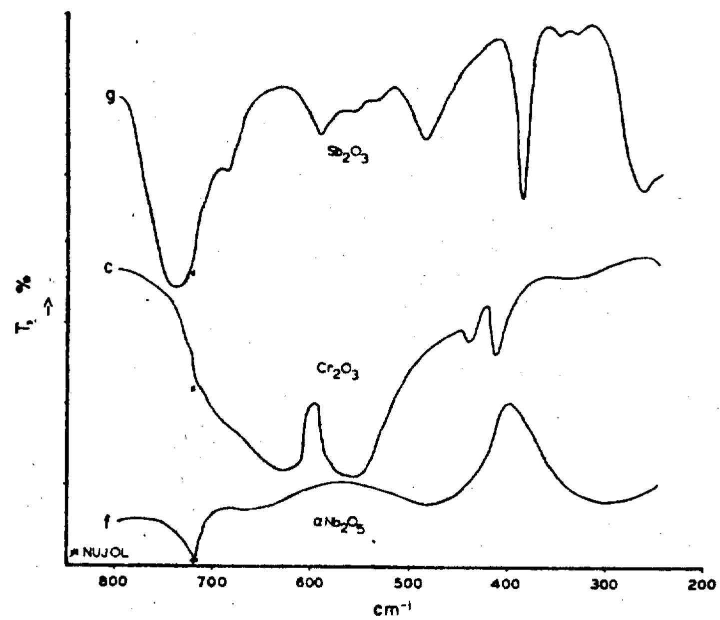

Fig. 3. Examples of spectra that can be obtained from metal oxides. g—Sb_2O_3; e—Cr_2O_3; f—αNb_2O_5.

grinding. The spectra for both compounds show two symmetrical absorption bands with the higher frequency band the more intense in each case.

Unlike the red mercuric oxide, the initial spectrum of MnO_2 (Fig. 2) gave very little indication that any characteristic absorption bands were present. This compound is shown as the extreme example of the necessary amount of grinding required to obtain a spectrum. More than 120 sec of grinding in a steel vial was required to thoroughly diminish the particle size of the sample so that a representative curve could be obtained. In most cases grinding for this length of time usually causes some undesired changes and possible phase transformations [23]. If a representative curve cannot be obtained after 120 sec of grinding the compound probably does not have a characteristic absorption spectrum in this region.

The general appearance of spectra obtained from metal oxides can be classified in three categories, i.e., good, average and poorly defined. The curves shown in Fig. 3 represent examples of these types. Curve G, Sb_2O_3, illustrates a good spectrum (about 10 per cent of the spectra studied), curve E, Cr_2O_3, is an average

[23] F. Dachille and R. Roy, *Nature* **186**, 34 (1960).

spectrum, while F, αNb_2O_5, represents a poor spectrum (about 10 per cent of the compounds studied).

Rare-earth oxides

The spectra for a group of rare-earth oxides [24] (Lu_2O_3, Yb_2O_3, Tm_2O_3, Er_2O_3, Y_2O_3, Ho_2O_3, Dy_2O_3, Gd_2O_3) give a well defined characteristic band in the region 570–530 cm^{-1}. Figure 4 shows a spectrum of a typical type C rare-earth, ytterbia, and a plot of frequency against unit cell dimension for the type C (cubic) oxides.

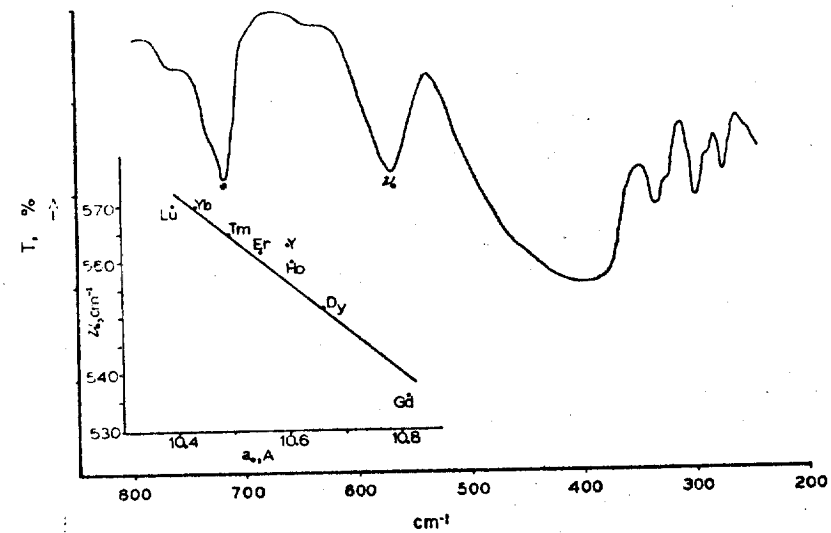

Fig. 4. Spectrum of a typical type C rare-earth oxide, ytterbia. Graph shows a plot of frequency against unit cell dimension of type C oxides.

The linear relation indicates a correlation with the high frequency band and the unit cell size. The type A (hexagonal) and type B (monoclinic) rare-earth oxides give different spectra from one another and the type C compounds. The optical properties [25] of the rare-earth oxides are becoming of interest, and distinguishing between one crystal structure and another can be of importance. An example of this is gadolinium sesquioxide, which can exist as type A, B, or C. In this study the infrared spectrum indicated the compound was of type C, removing any uncertainty as to its crystal structure.

Polymorphism

One of the more important determinations of this study is the role that polymorphism plays in characterizing the infrared spectrum of a compound. An oxide spectrum can be misleading if only the molecular formula is given when the particular compound can exist in several forms. An example of such an ambiguity

[24] W. L. Baun and N. T. McDevitt, *J. Am. Ceram. Soc.* **46**, 294 (1963).
[25] S. S. Batsanov, G. N. Grigor'eva and N. P. Sokolova, *J. of Structural Chem.* (*U.S.S.R.*) **3**, 323 (1962).

can be seen in spectrum 159G (TiO_2) in Reference [3]. Titanium dioxide has two commonly occurring crystal structures, anatase and rutile, and each gives a different infrared spectrum. These spectra can be seen in Fig. 5. The anatase structure has a very characteristic band at 347 cm^{-1}, whereas the rutile spectrum is quite different. Spectrum 159G in Reference [3] can now be identified as TiO_2 with an anatase structure. The infrared spectra of the polymorphic forms of TiO_2 have been studied in the rock salt region [6]. However, the results left much to be desired as a quick means of identifying the above compounds.

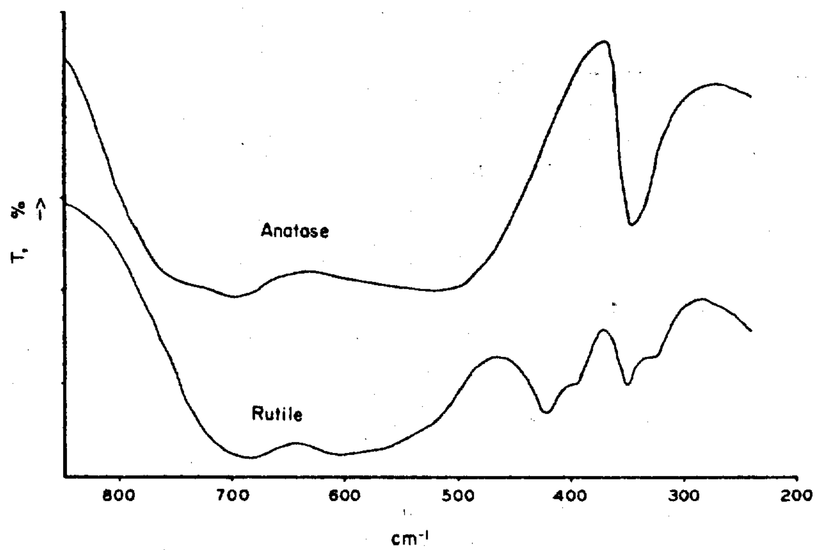

Fig. 5. Spectra of the polymorphic forms of titanium dioxide.

The present study includes several other polymorphic compounds namely, αFe_2O_3 and γFe_2O_3, αNb_2O_5 and δNb_2O_5, and αTa_2O_5 and βTa_2O_5. Their frequencies can be obtained from Table 1, and although the fundamental structural differences are in most cases slight, the infrared spectra serve to distinguish the various polymorphic forms.

Comments on individual compounds

An interesting pair of compounds are zirconia and hafnia. The metals of these compounds have very similar chemical properties in spite of the large difference in their atomic weights. It is understandable then that ZrO_2 and HfO_2 have similar properties such as a monoclinic crystal structure at room temperature. This similarity can be seen in the infrared spectrum where each curve shows seven absorption bands with closely related frequencies. However, both compounds can be easily identified from the different band shapes as can be seen in Fig. 6 (zirconia and hafnia show no absorption bands in the rock salt region of the infrared). Since the concentration in KBr was less than 1 per cent it is evident that these compounds absorb strongly in this region. Application of this region to research on ZrO_2 has been discussed elsewhere [26]. A typical example can be seen by comparing the frequencies of monoclinic ZrO_2 to the cubic form (stabilized with CaO) in Table 1.

Eight of the spectra listed in Table 1 are shown as having "No bands" in the region studied. Several of these compounds (BaO_2 and In_2O_3), however, do show some indication of a beginning of a large broad band with the high frequency side starting around 450 cm^{-1}. The BeO spectrum shows only the low frequency side of a very broad band that has its maximum absorption frequency at approximately 830 cm^{-1}. PbO_2 and CdO are unusual compounds in that they have no apparent

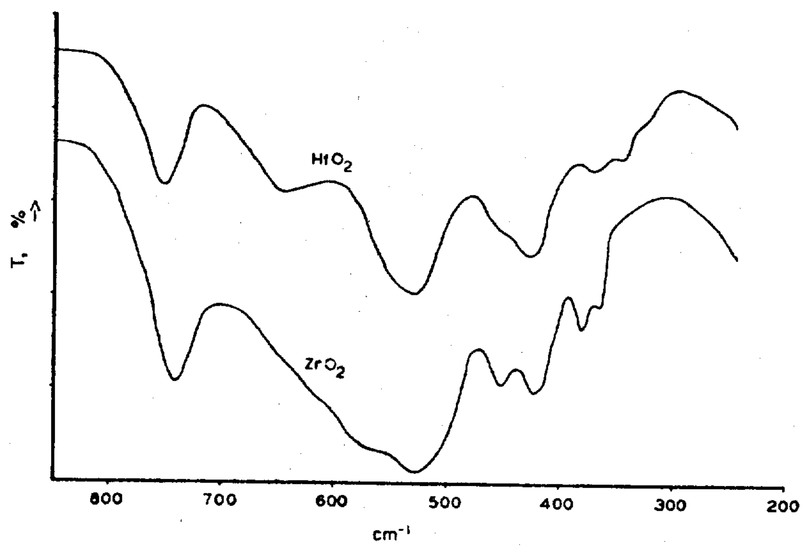

Fig. 6. Spectra of two similar compounds, hafnia and zirconia.

absorption bands between 4000 and 240 cm^{-1}. The infrared transmission of each material varies with frequency, but in both cases the change occurs over a very wide range. The concentration of the samples was greater than 1 per cent in KBr so the absence of absorption bands cannot be considered as a lack of sample in the matrix.

Comparison of individual studies in the literature with the data presented here is in good agreement with a few exceptions. PARODI [16] reports CuO as having one band at 263 cm^{-1} while the CuO spectrum in this paper shows bands at 610, 500 and 410 cm^{-1}. Analysis of our compound showed it to be at least 95 per cent monoclinic CuO. Other C.P. grades labeled CuO were checked by X-ray diffraction and found to contain large amounts of Cu_2O. Without knowing the purity of Parodi's CuO the above discrepancy is not resolvable at this time. Much of the data on oxides reported by VRATNY and co-workers [27] for the region 5000–416 cm^{-1} do not agree with frequencies reported here. For example, the HgO spectrum reported in Reference [27] shows only one strong band at 574 cm^{-1}. This compound

[26] N. T. McDEVITT and W. L. BAUN, *J. Am. Ceram. Soc.* (In press).
[27] F. VRATNY, M. DILLING, F. GUGLIOTTA and C. N. R. RAO, *J. Sci. Ind. Research* **20B**, 590 (1961).

is probably the red HgO and proper sample preparation was not taken into consideration (see Fig. 1). In this same paper the spectrum of Sb_2O_3 is poorly presented, because the spectrum from the same compound shows well defined bands in Ref. [3] and also this paper (Fig. 3).

Conclusion

In most cases the transmission spectra of the metal oxides exhibited broad absorption bands in the region studied. Therefore, sample preparation with respect to particle size is the most important factor when recording the infrared spectra of these compounds. The larger the particle size of the material the wider the apparent band width becomes. The data from this study indicates the particle size should be 10 μ or smaller for this region of the infrared in order to obtain a representative spectrum. Small differences in crystal structure can also be detected, giving rise to a valuable tool for the study of polymorphism and an aid in the research of refractory metal oxides.

The data presented here should serve as a powerful qualitative tool for the identification of and research on metal oxides.

Acknowledgements—The authors wish to thank F. F. Bentley for his interest and discussions on the spectra used in this study.

the less-developed countries are increasingly turning to auxiliary workers, or technical assistants.

The problem of obtaining adequate information for social programmes is in part that of balancing the use of limited resources; but reliance on social research as a basis for formulating, checking and evaluating systematic plans and programmes is increasing, and more attention is being given to experimentation and small trials before launching large projects. In regard to finance, however, there is little agreement as to what constitutes balanced development or a balanced allocation of funds for simultaneous economic and social development, or as to the order and timing of expenditures on different types of programme; nor does a chapter in the survey dealing specifically with research and surveys in connexion with social programmes warrant any confidence that a more detailed framework of thought to guide specific decisions is either possible or desirable.

This chapter is well documented and gives a brief picture of the organization of government research in various countries, as well as of such recent developments in the technique of research into social problems as the sample survey and the interdisciplinary approach, known as operational research. While, however, the increase in government statistical activities, especially in the under-developed areas, is emphasized, little information is given, or appears to be available, as to expenditure on social research. In the United States it amounts to some 2–3 per cent of the Federal expenditure on research, but no figures are given for other countries. In Norway public research expenditure rose from 14·7 million kroner in 1938 to 83·4 million kroner in 1952, and total expenditure on public and private research and development (both civil and military) is estimated at about 1 per cent or more of gross national expenditure in the German Federal Republic, Great Britain, the Netherlands, the United States and the U.S.S.R. In the economically developed countries, non-military research expenditure appears to be between 0·3 and 1 per cent of national income, but in undeveloped countries it is much less. During the decade ending 1952, population censuses were conducted in 155 out of 239 areas of the world, covering nearly 60 per cent of the world's population. Ninety-five countries and territories have taken on agricultural censuses within the framework of the 1950 World Census of Agriculture, and since 1948 more than thirty countries or territories have published a general statistical bulletin for the first time. In general, however, the role of the social scientist in relation to social policy appears to be uncertain.

The remaining chapters of the survey deal separately with health, nutrition, education, labour and social security programmes; with the programmes to improve housing and community facilities and to aid the consumer; and with special programmes of social protection and rehabilitation, or of social development for rural areas; and with general approaches to social development.

A DIETARY DEFECT IN MAIZE DEVELOPED DURING TREATMENT WITH LIME

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IN a recent appraisal of the state of knowledge on pellagra[1], it was agreed that the problem of the pellagragenic properties of maize is not yet solved and that the etiology of the disease is by no means simple. The incidence of pellagra is reported to be low in some regions of Mexico where the consumption of maize is high; the explanation of this is not clear —it may be that the disease is not diagnosed or reported, that the diet contains some foods, for example, beans, which protect the consumer, or it may be the result of the method of preparing the maize grain for making tortillas. The last of these possible explanations has led to several investigations on the effects on the nutritive value of maize when treated with lime in the Mexican manner.

Krehl *et al.*[2] found no difference between rats fed on lime-treated or raw maize. However, Laguna and Carpenter[3], Cravioto *et al.*[4] and Squibb *et al.*[5] reported that rats fed on lime-treated maize grew better than rats given untreated maize; these results have been confirmed in our laboratory. Recently, Braude *et al.*[6] reported the curative effect on pellagra in pigs of maize which had been partially hydrolysed with sodium hydroxide; but Goldsmith *et al.*[7] were unable to demonstrate any beneficial effects of lime-treated maize in human pellagrins.

The effect of lime on the nutritive value of maize has been ascribed either to an increase in 'available' nicotinic acid following hydrolysis with alkali of a 'bound' form[3,4], or to the racemization of certain amino-acids, thereby avoiding amino-acid imbalance in the diet[4]. The highly critical nature of the balance of amino-acids for growth has been emphasized in a recent paper by Elvehjem and Harper[8].

The diets of the rats in the three previously reported experiments on the effect of lime-treatment of maize have contained adequate amounts of the known B-vitamins except nicotinic acid, the investigators having been concerned primarily with the effects of lime on the availability of nicotinic acid. However, since lime-treated maize, when substituted for untreated maize in human dietaries, may not be combined in diets with foods supplying adequate amounts of B-vitamins, experiments have been made on the effects on rats of diets consisting mainly of lime-treated or untreated maize and without supplements of the B-vitamin complex.

The results obtained in three separate experiments are summarized in Table 1, from which it can be seen that: (i) the rate of growth of the rats fed on lime-treated maize was significantly lower than that of the rats on untreated maize; (ii) supplementation of the diet with either nicotinic acid or tryptophan had no effect on this depressed growth-rate; (iii) on addition to the diet containing lime-treated maize of aureomycin or of a mixture of B-vitamins, the

Table 1. Weight Gains of Rats upon Raw and Lime-treated Diets with and without Various Supplements

Experiment	Diet (a) No.	Maize	Supplement	No. of rats	Average weight-gain (4 weeks) gm.	Average weight-gain per 100 gm. food eaten (4 weeks) gm.	P*
A	I	Raw	None	6	59·3	23·5	< 0·001
	II	Lime	None	6	40·5	18·9	
	III	Raw	Aureomycin (b)	6	65·2	24·9	
	IV	Lime	Aureomycin (b)	6	64·7	25·1	
B	I	Raw	None	6	56·5	21·8	< 0·01
	II	Lime	None	6	39·5	18·1	
	III	Raw	Aureomycin (b)	6	53·2	20·8	
	IV	Lime	Aureomycin (b)	6	50·0	21·6	
	V	Raw	Nicotinic acid (c)	6	58·7	22·6	
	VI	Lime	Nicotinic acid (c)	6	37·3	16·6	
C	I	Raw	None	6	49·7	21·7	< 0·001
	II	Lime	None	6	27·3	15·0	
	VII	Raw	B vitamins (d)	6	64·8	23·9	
	VIII	Lime	B vitamins (d)	6	60·2	23·0	
	IX	Raw	Tryptophan (e)	6	50·0	20·1	
	X	Lime	Tryptophan (e)	6	27·8	15·0	

* Analysis of variance technique used. Effects of diet differences shown to be highly significant when results of weight-gain per 100 gm. food were analysed.

(a) Diet: casein (alcohol extracted) 3 per cent, salt mixture (de Loueiro) 4 per cent, sucrose 5 per cent, lard 3 per cent, maize (raw or lime-treated) 85 per cent. The method of lime-treatment of maize was that of Cravioto (ref. 9).

(b) Aureomycin: 10 mgm. per 100 gm. diet.

(c) Nicotinic acid: 3 mgm. per 100 gm. diet.

(d) B vitamins (all per 100 gm. of diet): choline 200 mgm., inositol 100 mgm., para amino-benzoic acid 44 mgm., thiamine hydrochloride 1·0 mgm., riboflavin 1·2 mgm., pyridoxine 1·0 mgm., calcium *d*-pantothenate 2·0 mgm., biotin 0·2 mgm., folic acid 0·6 mgm., nicotinic acid 3·0 mgm.

(e) Tryptophan: 100 mgm. per 100 gm. diet.

growth-rate was the same as that of rats on a diet of untreated maize.

It was suspected from a consideration of these experiments that the lime-treated maize contained less of some of the vitamins of the B-complex than untreated maize, probably of those known to be required for growth and alkali-labile, namely, riboflavin and thiamine. According to Cravioto *et al.*[9] vitamins are not destroyed during lime treatment; but Zozaya and Alvarado[10] have reported that riboflavin was absent from tortillas and Squibb *et al.*[5] have reported losses of 32–42 per cent of total nicotinic acid during lime treatment.

Analysis of raw and lime-treated maize for total nicotinic acid, riboflavin and thiamine revealed (Table 2) considerable losses of all three vitamins during lime treatment and, since it was known from previous experiments that additions of nicotinic acid did not affect the depressed rate of growth, the possibility that it was due to insufficiency of riboflavin or thiamine was investigated.

Table 2. Vitamin Content of Raw and Lime-treated Maize

Vitamin	Method of analysis	Content in µgm/gm. (water content 9–10 per cent) Raw	Lime-treated
Nicotinic acid	Microbiological: *Lactobacillus arabinosus*	18·0 18·6	12·0 10·5
Riboflavin	Microbiological: *Lactobacillus casei e*	1·4 1·6	0·6 0·8
Thiamine	Chemical: thiochrome	5·3 5·0	1·0 1·1

The results in Table 3 show that addition of either riboflavin or thiamine to lime-treated maize produced an increased growth-rate as compared with that of the control animals.

The effect of riboflavin was much greater than that of thiamine, and the weight gain on the former of about 2·2 gm. per rat daily is close to that of 2·1 gm. per day for rats of similar weights on the diet with the vitamin B-complex supplement. It appears, then, from these results that the main cause of the retarded growth of animals on lime-treated maize is an inadequate amount of riboflavin consequent on destruction during lime treatment of the grain; the thiamine intake is probably marginal and the growth increase obtained with aureomycin may be due to a vitamin-sparing action effected in some way by the microflora of the gut of the rat.

The low incidence of pellagra reported from Mexico and the possibility of this being due to the alleged beneficial effects of lime-treated maize has led to some trials in Southern Rhodesia[11] with a view to the introduction of the process into a region in which the prevention of pellagra is a problem.

The substitution of lime-treated for whole maize meal would have the merit of increasing the amount of calcium in the diet, of raising the proportion of the total nicotinic acid in the grain in 'available' (that is, unbound) form, though from Table 2, about a third of the total may be lost and, since the 'bran' of the grain is removed in lime treatment, digestion and absorption of the treated product might be improved.

The disadvantages would include substantial reduction in the amounts of riboflavin and thiamine.

Table 3. Average Weight-gains of Animals fed on Lime-treated Maize and Supplement of Riboflavin or Thiamine

Diet	No. of rats	Initial average weight (gm.)	S.E.*	Average weight after 10 days dosing (gm.)	S.E.*	Average weight gain (gm.)
Lime-treated maize	4	62·5	6·1	69·0	7·3	6·5
Lime-treated maize + riboflavin	4	56·0	3·3	78·0	3·8	22·0
Lime-treated maize + thiamine	4	61·7	3·8	75·0	4·8	13·3

* Standard error of the mean.

All animals had previously been on a lime-treated unsupplemented diet for 4 weeks. The supplements were 150 µgm. daily of riboflavin or thiamine for a period of 10 days.

The amount of riboflavin in the traditional diets of the tribes of Central Africa having maize as their staple food may be low. Platt and Webb[12] estimate a content of 1·13 mgm. riboflavin for a 3,060 Cal. diet (not containing grain 'beer'); the allowance of riboflavin recommended by the British Medical Association Committee[13] is 1·8 mgm. for a male adult on a 3,000 Cal. diet. In the dietaries of sophisticated African communities whole maize meal (machine-milled grain) frequently replaces the domestically prepared maize flour, and in such dietaries the amount of vegetables and fruit, which are important sources of riboflavin, is often much less than in the traditional dietary.

It is important in this connexion to note that one of us (B. S. P.) has worked throughout the year in the Central African territory of Nyasaland, where the people obtain sometimes as much as three-quarters of their energy from maize, and yet, in the rural areas, pellagra was never seen. The maize flour used was prepared by the women by a process widely used throughout Africa which includes soaking and fermentation. The use of such flour may have contributed to the absence of pellagra; the extensive consumption of grain 'beer'[14] may also be a factor[12,14].

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[Nov. 22

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MEANING OF DEUTERIUM ABUNDANCE IN METEORITES

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THE article by G. Edwards on the "Isotopic Composition of Meteoritic Hydrogen"[1] contains some very questionable statements about the meaning of the deuterium content of meteorites and an incorrect interpretation of the results and conclusions reached by me on the same subject[2].

The significance of the determination of the D/H ratio in planetary objects in connexion with the problem of the origin and the formation of the solar system was pointed out a few years ago by Urey[3] and by Kuiper[4] and was discussed in detail more recently by me[2a]. Some further comments can be added here.

The isotopic evidence may be used in the following way. First, it is necessary to determine whether there is a definite difference between the deuterium content of the Earth and that of meteorites, these last being regarded as our only specimens of the material present in the planetary space outside the Earth. A definite difference, namely, a difference of more than one average fractionation stage, would suggest that an enrichment process other than ordinary chemical fractionation had operated on the hydrogen isotopes at some time between the initial accumulation of the planetary bodies and the present time. The lack of such a definite difference in the carbonaceous chondrites, together with the other experimental evidence, suggested to me that the primoval cosmic abundance of deuterium could not be different from the terrestrial abundance within a factor of the order of a chemical fractionation stage. Such a conclusion is supported also by the data of Edwards on the iron meteorites.

The second step to be taken is a more detailed study of deuterium abundance in different types of meteorites and different hydrogen compounds, in order to understand which fractionation processes are responsible for the observed variations. This kind of work requires a large number of analyses carried out in a systematic manner, since the experimental method is delicate and additional evidence is generally lacking. Thus I feel that the limited amount of knowledge on the origin of the meteorites and the small number of deuterium analyses make meaningless at the present time such questions as whether the D/H ratio in the iron meteorites is more 'reliable' than the D/H ratio in carbonaceous chondrites, as Dr. Edwards tries to prove in his article. The detailed reasons for this will be given at the end of this article.

In attempting to demonstrate that his results are more conclusive than mine, Dr. Edwards makes two main criticisms of my work: (1) that I "attached special significance" to some specific results; (2) that my analytical data may be wrong, since Wiik[5] found systematically higher water contents in his chemical analyses of the carbonaceous chondrites.

So far as the first point is concerned, my interpretation of the significance of the *four* results showing deuterium content outside the range of terrestrial variations was clearly stated. It was only one additional proof that we were dealing with true meteoritic water, but it was never stated that "special significance [was attached] to the three results in which he found deuterium to be more than 25 per cent higher than in Lake Michigan water" (quote from Edwards's paper). I would like to emphasize that I never said that the concentration of deuterium in the planetary space was 25 per cent higher than that on the Earth.

The second point, that is, the difference between Wiik's results and mine on the total water content needs a little more attention. The reason for the divergence—which Dr. Edwards perhaps did not

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THE FLAME-PHOTOMETRIC DETERMINATION OF CaO IN FODDER AND SOILS

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Phosphates, iron ions, and especially aluminum ions disturb the flame-photometric determination of calcium to a considerable extent. According to my experience, using this determination for 100 ml solutions containing 10 mg Al in addition to 50 mg CaO, I obtained CaO-contents decreased by 25%. When fodder and soils were tested, the CaO-deficits sometimes went down to 35%. Several investigators have attempted to eliminate these errors without being able to arrive at, for practical purposes, useful results (1)(2). In their work, Gjems and Lüdersen (2) attempted to eliminate these errors by using precipitation of aluminum as aluminum benzoate. However, this method is only successful in cases in which only very small quantities of P_2O_5 are present. This method does not give useful results for the analysis of fodder. According to the method developed by Schneider (3), the CaO-content is determined by the addition of ammonium citrate and precipitation of P_2O_5 with magnesia mixture. The deviations from the gravimetrically

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*) Miss A. Reiner, Technical Assistant, is thanked for her cooperation in carrying out the experiments.

found values are still relatively high.

The flame-photometer used was a rebuilt old Schuhknecht-Waibel apparatus into which the selenium cell S_{28} of the concern Lange had been built in as photo-element. The falem was produced by an acetylene - air mixture. The filter KR_1 of the concern Musterschmidt, Goettingen, served as color filter. This filter showed a certain transmittancy for lines generated by potassium compounds, hence, the galvanometor deflections measured for CaO in the presence of potassium had to be corrected. It turned out that under the described conditions of operation, the corrections were independent of the CaO-quantity and proportional to the quantity of potassium present. Thus, it is necessary to determine the quantity of potassium when this color filter is used, but this is easy to accomplish flame-photometrically. It is probable that this condition can be eliminated by the use of interference filters or other suitable color filters.

The disturbance of the determination by the presence of phosphoric acid depends upon the P_2O_5-content and the CaO-content of the solutions to be analyzed. Köhnlein and Lücke (1) established that with increasing addition of P_2O_5 to constant CaO-quantities, the galvanometer deflections decreased only until a certain phosphate concentration had been reached (CaO: P_2O_5 = 1.23) whereas from this point on, the galvanometer deflections remained constant at higher P_2O_5-quantities. One can use this result in the Ca-determination by beforehand adding so much phosphate that this CaO : P_2O_5 ratio is surpassed even at the highest CaO-quantity to be expected. Hence, I have added to each CaO-determination 100 mg P_2O_5 as $(NH_4)_2HPO_4$ or $(NH_4)H_2PO_4$.

It is much more difficult to eliminate the disturbance caused by iron- or aluminum ions. This purpose was not accomplished by the addition of tartrate- or citrate ions for complexing iron and aluminum. The most suitable method proved to be the precipitation of the sesquioxides with ammonium acetate and the flame-photometric determination of the CaO-content in the filtrate. This is best accomplished as follows: To an aliquot of the ash dissolved in HCl

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which should contain 1 ml of 25% HCl, one adds 2 ml phosphate solution (100 mg P_2O_5), transfers this solution to a 100 ml flask, dilutes with water to about 70 ml, and heats to boiling. Then, one adds 4 ml of a 50% ammonium acetate solution and brings the solution again to a boil for a short time. After the solution has been allowed to cool, it is filtered through a fluted filter, and the filtrate is atomized in the flame-photometer. Care has to be taken that the ammonium acetate is added to the boiling solution and that filtration is carried out even when no visible precipitate has been formed. One prepares the standard solutions for standardizing the flame-photometer by introducing a solution of 1, 2 ....10 mg CaO into a 100 ml flask, adding 1 ml of 25% HCl, 2 ml ammonium phosphate solution, 4 ml ammonium acetate solution, and filling up with water to 100 ml.

The results reported in the following Table confirm that this relatively simple method gives useful results for the Ca-content of fodder. For 41 fodder samples, the CaO-quantities determined by precipitation with ammonium oxalate were compared with the values obtained by flame-photometry. It turned out that in the case of 54% of all the samples, the CaO-contents determined by flame-photometry deviated from the values determined with ammonium oxalate by less than 5%. In the case of about a third of the samples, errors between 5 and 10% were obtained. In the case of 14.5% of the tests, the error was somewhat greater than 10%.

In the case of the 9 bog samples which were analyzed, it is doubtful whether these few results allow us to draw any conclusions at all. At any rate, the found deviations are somewhat greater, but remain approximately in the same order of magnitude (see the Table).

TABLE

Sample No.	Material	% CaO with NH4-Oxalate	% CaO flame photometrically	% Error relative	% Error absolute
2000	Hay	2.60	2.63	+0.03	+ 1.1
2072	Silage	2.00	1.97	-0.03	- 1.5
2213	"	1.74	1.70	-0.04	- 2.3
2214	"	2.17	2.03	-0.14	- 8.2
2221	"	0.81	0.76	-0.05	- 6.1
2379	Topped Beets	0.38	0.40	+0.02	+ 5.3
1919	Silage	2.00	1.81	-0.19	- 9.3
2420	"	1.10	0.98	-0.12	-10.9
2421	"	1.31	1.34	+0.03	- 2.3
2422	"	1.31	1.27	-0.04	- 3.0
2423	"	0.97	1.00	+0.03	+ 3.1
2810	Nettles	1.64	1.56	-0.08	- 4.9
2827	Hay	1.23	1.24	+0.0	+ 0.8
2828	Grass	0.84	0.92	+0.08	+ 9.5
2837	Dried Green Fodder	0.76	0.76	0	0
2839	"	0.63	0.70	+0.07	+11.1
2842	Early grass	0.98	1.05	+0.07	+ 7.2
2863	Landsberg Mixture	1.45	1.60	+0.15	+10.3
2864	Dried Green Fodder	0.70	0.80	+0.10	+14.3
2865	"	0.97	1.05	+0.08	+ 8.3
2881	Green Meal	1.07	1.08	+0.01	+ 0.9
2882	"	0.75	0.78	+0.03	+ 4.0
2883	"	0.70	0.73	+0.03	+ 4.3
2884	"	0.60	0.78	+0.09	+13.1
2885	"	0.75	0.80	+0.05	+ 6.7
1996	Dried Beet Chips	1.40	1.34	-0.06	- 4.2
1997	Troblaco*)	1.21	1.14	-0.07	- 5.8
1998	Hay	0.89	0.86	-0.03	- 3.4
1999	"	1.16	1.12	-0.04	- 3.4
2001	"	2.60	2.52	-0.08	- 3.1
2002	Pea Straw	1.50	1.48	-0.02	- 1.3
2525	Silage	0.41	0.40	-0.01	- 2.4
2543	Grass	0.83	0.76	-0.07	- 8.4

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*) (Translator's Remark:) Troblaco® is a rich fodder, especially suited for dairy cattle which consists of sugar beet leaves with topped beets and is artificially dried. 1000 parts contain 113 parts crude protein, 72 parts digestible protein, and 508 starch units (Hermann Römpp, "Chemie Lexikon", 6th ed., Stuttgart, 1966 p. 6674).

Table continued.

1976	Silage	2.10	2.25	+0.15	+ 7.1
1977	Troblaco*)	1.93	1.81	+0.12	- 6.4
2335	Silage	1.26	1.27	+0.01	+ 0.8
2434	WheatBran	0.75	0.72	-0.03	- 4.0
2436	Coarse Soybean Meal	0.46	0.46	0	0
2437	Coarse Peanut Meal	0.26	0.25	-0.01	- 3.8
2438	Coarse Palm-Kernel Meal	0.52	0.58	+0.06	+11.5
2505	Orchard Grass	1.71	1.60	-0.09	- 6.4
1036	Bog Soil	0.66	0.73	+0.07	+10.6
745	"	2.27	1.92	-0.29	-15.4
746	"	2.82	2.52	-0.30	-10.7
747	"	2.12	2.07	-0.05	- 2.4
748	"	1.96	1.84	-0.12	- 6.1
749	"	1.89	1.88	-0.01	- 0.5
750	"	2.28	2.10	-0.18	- 7.9
751	"	4.24	3.92	-0.32	- 7.5

Carrying Out the Determination

Solutions Required

1. CaO -- Dissolve 1 g CaO (analysis grade) in a small quantity of HCl and fill up to 1 liter with H_2O, 1 ml = 1 mg CaO.
2. Dissolve 500 g ammonium acetate in water and dilute to 1 liter.
3. Dissolve 92 g $(NH_4)_2HPO_4$ in water and dilute to 1 liter.

Ash 2.5 g material, rinse into a 100 ml flask, treat with 10 ml of 25% HCl, and heat to boiling. After cooling, fill the flask to the mark. After dissolved parts have been allowed to settle for a short time, pipet 10 ml of the solution into a 100 ml flask, dilute with H_2O to about 70 ml, add 2 ml $(NH_4)_2HPO_4$ solution, and heat to boiling on the wire net. To the boiling solution, add 4 ml ammonium acetate solution, boil the solution again for a short time, cool, and filter through a fluted filter. Atomize the solution thus prepared in the flame photometer.

Standard Solutions -- Introduce 0.5, 1, ... 10 ml CaO into a 100 ml flask, add 1 ml of 25% HCl, 2 ml $(NH_4)_2HPO_4$ solution, 4 ml ammonium acetate solution, and fill up to 100 ml.

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Beitrag zur flammenphotometrischen CaO-Bestimmung in Futtermitteln und Böden

(Aus dem Landw. Untersuchungsamt u. Versuchsanstalt Oldenburg der Landwirtschaftskammer Weser-Ems; Direktor: F. Nieschlag)

Von H. Westerhoff[1])

(Eingegangen am 20. 10. 1954)

Phosphate, Eisen- und besonders Aluminiumionen stören die flammenphotometrische Bestimmung des Calciums sehr erheblich. Nach eigenen Erfahrungen wurden in Lösungen, die in 100 ml neben 50 mg CaO noch 10 mg Al enthielten, Mindergehalte an CaO von 25% festgestellt. Bei der Untersuchung von Futtermitteln und Böden ergaben sich teilweise Mindergehalte bis 35% CaO. Mehrere Autoren haben sich bemüht, diese Fehler auszuschalten, ohne jedoch zu praktisch brauchbaren Ergebnissen zu gelangen (1, 2). In der Arbeit von Gjems und Lüdersen (2) wird versucht, diese Störungen der CaO-Bestimmung durch Ausfällen des Aluminiums mit Hilfe von Aluminiumbenzoat zu beseitigen. Dies gelingt aber nur in Fällen, in denen sehr wenig P_2O_5 anwesend ist. Bei Futtermitteln liefert diese Methode keine brauchbaren Ergebnisse. Nach der von Schneider (3) ausgearbeiteten Methode wird der CaO-Gehalt nach Zusatz von Ammonzitrat und Abscheidung der P_2O_5 mit Magnesiamischung vorgenommen. Die Abweichungen von den gravimetrisch ermittelten Werten sind aber noch verhältnismäßig hoch.

Als Flammenphotometer diente ein umgebautes altes Schuhknecht-Waibelgerät, in welches als Photoelement die Selenzelle S_{24} der Firma Lange eingebaut worden war. Die Flamme wurde durch Acetylen/Luftgemisch erzeugt. Als Lichtfilter wurde das Filter KR_1 der Firma Musterschmidt, Göttingen, verwendet. Da dieses Filter aber eine gewisse Durchlässigkeit für durch Kaliverbindungen erzeugte Linien zeigte, mußten die bei Anwesenheit von Kali durch CaO gemessenen Galvanometerausschläge korrigiert werden. Es zeigte sich aber, daß diese Korrekturen unter den gegebenen Arbeitsbedingungen unabhängig von der CaO-Menge und der vorhandenen Kalimenge proportional waren. Es ist bei Verwendung dieses Lichtfilters zwar erforderlich, die vorhandene Kalimenge zu ermitteln, doch läßt sich dies flammenphotometrisch sehr leicht durchführen. Durch Verwendung von Interferenz- oder sonstigen geeigneten Lichtfiltern läßt sich dieser Umstand aber wahrscheinlich leicht beseitigen.

Die Störung der Bestimmung durch vorhandene Phosphorsäure ist abhängig von dem P_2O_5- und dem CaO-Gehalt der zu untersuchenden Lösungen. Köhnlein u. Lücke (1) haben festgestellt, daß bei steigendem Zusatz von P_2O_5 zu konstanten CaO-Mengen die Galvanometerausschläge nur bis zu einer bestimmten Phosphatkonzentration (CaO : P_2O_5 = 1,23) abnahmen, um dann bei höheren P_2O_5-Mengen konstant zu bleiben. Diesen Befund kann man sich nun bei der Ca-Bestimmung insofern zunutze machen, als man von vornherein der zu untersuchenden Lösung soviel Phosphat zufügt, daß dieses CaO : P_2O_5-Verhältnis auch bei der höchsten zu erwartenden CaO-Menge überschritten wird. Ich habe deshalb zu jeder CaO-Bestimmung 100 mg P_2O_5 als $(NH_4)_2HPO_4$ oder $NH_4H_2PO_4$ zugefügt.

Weit schwieriger ist es, die durch Eisen- und Aluminiumionen verursachte Störung auszuschalten. Zusatz von Tartrat- oder Zitrationen, um Eisen und Aluminium komplex zu binden, führten nicht zum Ziele. Als am besten geeignet erwies es sich, die Sesquioxyde mit Hilfe von Ammoniumacetat auszufällen und im Filtrat den CaO-Gehalt flammenphotometrisch zu ermitteln. Man verfährt dabei am besten so, daß man einen aliquoten Teil der salzsauren Aschenlösung, der 1 ml 25%ige HCl enthalten soll, mit 2 ml Phosphatlösung (100 mg P_2O_5) versetzt, in einem 100 ml Kolben auf ungefähr 70 ml mit Wasser verdünnt und zum Sieden erhitzt. Dann fügt man 4 ml 50%ige Ammonacetatlösung hinzu und läßt nochmals kurz aufkochen. Nach dem Abkühlen filtriert man durch ein Faltenfilter und zerstäubt das erhaltene Filtrat im Flammenphotometer. Es ist dabei darauf zu achten, daß das Ammonacetat zur siedenden Lösung gegeben wird und daß eine Filtration auch dann vorgenommen werden muß, wenn sich kein sichtbarer Niederschlag gebildet hat. Die Standardlösungen zur Eichung des Flammenphotometers werden hergestellt, indem man in einem 100-ml-Kölbchen zu einer Lösung von 1, 2 .... 10 mg CaO, 1 ml 25% HCl, 2 ml Ammonphosphatlösung und 4 ml Ammonacetatlösung hinzugibt und auf 100 ml mit Wasser auffüllt.

Daß diese verhältnismäßig einfache Methode brauchbare Werte für den Ca-Gehalt von Futtermitteln ergibt, wird durch die Befunde der folgenden Tabelle erhärtet. Es wurden bei 41 Futtermittelproben die durch Fällen mit Ammonoxalat erhaltenen CaO-Mengen mit den flammenphotometrisch ermittelten verglichen. Es zeigte sich dabei, daß bei 54% aller Proben die Abweichung der flammenphotometrisch ermittelten CaO-Gehalte von den mit Ammonoxalat ermittelten Werten unter 5% lag. Bei ungefähr einem Drittel der Proben ergaben sich Fehler zwischen 5 und 10%. Bei 14,5% der Untersuchungen war der Fehler etwas größer als 10%.

Bei den 8 untersuchten Moorböden sind die ermittelten Abweichungen, sofern diese wenigen Befunde überhaupt einen Schluß erlauben, zwar etwas größer. Sie bewegen sich aber in ungefähr derselben Größenordnung (siehe nebenstehende Tabelle).

Nr. der Probe	Bezeichnung	% CaO m. NH_4-oxalat	% CaO flammenphotometrisch	% Fehler relativ	% Fehler absolut
2000	Heu	2,60	2,63	+0,03	+ 1,1
2072	Silofutter	2,00	1,97	−0,03	− 1,5
2213	.	1,74	1,70	−0,04	− 2,3
2214	.	2,17	2,03	−0,14	− 8,2
2221	.	0,81	0,76	−0,05	− 6,1
2379	G. K. Rüben	0,38	0,40	+0,02	+ 5,3
1919	Silofutter	2,00	1,81	−0,19	− 9,5
2420	.	1,10	0,98	−0,12	−10,9
2421	.	1,31	1,34	+0,03	+ 2,3
2422	.	1,31	1,27	−0,04	− 3,0
2423	.	0,97	1,00	+0,03	+ 3,1
2810	Brennessel	1,64	1,56	−0,08	− 4,9
2827	Heu	1,23	1,24	+0,01	+ 0,8
2828	Gras	0,84	0,92	+0,08	+ 9,5
2837	Trockengrünfutter	0,76	0,76	0	0
2839	.	0,63	0,70	+0,07	+11,1
2842	Junggras	0,98	1,05	+0,07	+ 7,2
2863	Landsb. Gemenge	1,45	1,60	+0,15	+10,3
2864	Trockengrünfutter	0,70	0,80	+0,10	+14,3
2865	.	0,97	1,05	+0,08	+ 8,3
2881	Grünmehl	1,07	1,08	+0,01	+ 0,9
2882	.	0,75	0,78	+0,03	+ 4,0
2883	.	0,70	0,73	+0,03	+ 4,3
2884	.	0,69	0,78	+0,09	+13,1
2885	.	0,75	0,80	+0,05	+ 6,7
1996	Trockenschnitzel	1,40	1,34	−0,06	− 4,2
1997	Troblaco	1,21	1,14	−0,07	− 5,8
1998	Heu	0,89	0,86	−0,03	− 3,4
1999	.	1,16	1,12	−0,04	− 3,4
2001	.	2,60	2,52	−0,08	− 3,1
2002	Erbsenstroh	1,50	1,48	−0,02	− 1,3
2525	Silofutter	0,41	0,40	−0,01	− 2,4
2543	Gras	0,83	0,76	−0,07	− 8,4
1976	Silofutter	2,10	2,25	+0,15	+ 7,1
1977	Troblaco	1,93	1,81	−0,12	− 6,4
2335	Silage	1,26	1,27	+0,01	+ 0,8
2434	Weizenkleie	0,75	0,72	−0,03	− 4,0
2436	Sojaschrot	0,46	0,46	0	0
2437	Erdnußschrot	0,26	0,25	−0,01	− 3,8
2438	Palmkernschrot	0,52	0,58	+0,06	+11,5
2505	Knaulgras	1,71	1,60	−0,09	− 6,4
1036	Moorboden	0,66	0,73	+0,07	+10,6
745	.	2,27	1,92	−0,29	−15,4
746	.	2,82	2,52	−0,30	−10,7
747	.	2,12	2,07	−0,05	− 2,4
748	.	1,96	1,84	−0,12	− 6,1
749	.	1,89	1,88	−0,01	− 0,5
750	.	2,28	2,10	−0,18	− 7,9
751	.	4,24	3,92	−0,32	− 7,5

Durchführung der Bestimmung:

Erforderliche Lösungen:

1. CaO: 1 g CaO zur Analyse wird in wenig HCl gelöst und zu einem 1 mit H_2O aufgefüllt, 1 ml = 1 mg CaO.

2. 500 g NH_4acetat werden zu 1 l in Wasser gelöst.

3. 92 g $(NH_4)_2HPO_4$ zu 1 l Wasser lösen.

2,5 g Substanz werden verascht, in ein 100-ml-Kölbchen übergespült, mit 10 ml 25%iger HCl versetzt und zum Sieden erhitzt. Nach dem Abkühlen wird bis zur Marke aufgefüllt. Man läßt die ungelösten Teile kurz absitzen und pipettiert 10 ml der Lösung in ein 100-ml-Kölbchen, verdünnt mit H_2O auf ungefähr 70 ml, fügt 2 ml $(NH_4)_2HPO_4$-Lösung hinzu und erhitzt auf dem Drahtnetz zum Sieden. Zur siedendheißen Lösung gibt man 4 ml NH_4-Acetatlösung, läßt nochmals

[1]) Der landw.-techn. Assistentin Frl. A. Reiners bin ich für die rege Mitarbeit bei der praktischen Durchführung der Versuche sehr dankbar.

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kurz aufkochen, kühlt ab, füllt zur Marke auf und filtriert durch ein Faltenfilter. Die so erhaltene Lösung wird im Flammenphotometer zerstäubt.

S t a n d a r d l ö s u n g e n: Zu 0,5; 1 .... 10 mg CaO in 100-ml-Kölbchen werden 1 ml 25%ige HCl, 2 ml $(NH_4)_2HPO_4$-Lösung und 4 ml NH_4-acetatlösung gegeben und auf 100 ml aufgefüllt.

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Karotingehalt und Heuqualität

(Aus dem Staatl. Forschungs- und Beratungsinstitut für Höhenlandwirtschaft, Donaueschingen, Direktor: Prof. Dr. Knoll)

Von K. P a p e n d i c k

(Eingegangen am 25. 9. 1954)

Eine wesentliche Karotinquelle ist das Heu, das zu den wichtigsten wirtschaftseigenen Futterstoffen gehört und die Grundlage einer normalen Winterfütterung im Viehstall bildet. Über den Karotingehalt von Wiesenheu liegen bisher verhältnismäßig wenige Ergebnisse vor, so daß es wünschenswert erschien, den Karotingehalt des Wiesenheues unter den örtlichen Bedingungen des Ostschwarzwaldes zu prüfen. Da das Karotin ein sehr empfindlicher Bestandteil der Nahrung ist, wurde außerdem die Frage untersucht, inwieweit Beziehungen zwischen dem Karotingehalt des Heues und seinem Gehalt an verdaulichen Nährstoffen bestehen, d. h. was der Karotingehalt über die Güte des Heues aussagen kann.

Unter Karotin versteht man heute die isolierbaren Vitamin-A-wirksamen Karotinoide α-, β- und γ-Karotin und Kryptoxanthin. In den üblichen Futterstoffen kommt hauptsächlich das β-Karotin vor. Karotin wirkt nicht selbst als Vitamin, sondern stellt die Vorstufe des in der Ernährung der Tiere so wichtigen Vitamins A dar. Aus den genannten Karotinoiden wird im Tierkörper, teils in der Leber, teils schon im Darm das Vitamin A gebildet. Dabei können aus α-Karotin, γ-Karotin und Kryptoxanthin je ein Teil Vitamin A und aus β-Karotin 2 Teile Vitamin A entstehen. Bei der Umwandlung des Karotins treten jedoch Verluste auf, weswegen die theoretisch mögliche Vitamin-A-Ausbeute praktisch niemals erreicht wird. Über die Größe der Umwandlungsverluste lassen sich noch keine allgemeinen quantitativen Aussagen machen. Deshalb betragen die für die Praxis angegebenen Bedarfsnormen im allgemeinen ein Vielfaches des physiologischen Minimums und schwanken nicht unerheblich.

Da alle grünen Pflanzen und die daraus gewonnenen Futterstoffe, also Grünfutter, Gärfutter, Heu, Grünmehle usw., kein Vitamin A, sondern nur die Vorstufe Karotin enthalten, ist das Karotin die einzige Vitamin-A-Quelle bei den Pflanzenfressern. Große Bedeutung kommt daher dem Karotingehalt des Futters besonders in der Milchviehfütterung zu.

Das Karotin ist wenig widerstandsfähig gegen äußere Einflüsse und erleidet mehr oder weniger starke Einbußen. Mit der Karotinzersetzung gehen die Verluste an anderen Bestandteilen des Futters einher. Da das Karotin jedoch wesentlich empfindlicher ist als die übrigen Nährstoffe, war zu vermuten, daß der Karotingehalt zur Beurteilung der Rauhfutterqualität, insbesondere auch des Heues, herangezogen werden kann. Der absolute Gehalt an Karotin hängt natürlich von verschiedenen Faktoren wie der Pflanzenart, dem Schnittzeitpunkt, der Konservierung, der Lagerung usw. ab. Man muß grundsätzlich unterscheiden zwischen Grünfutter und dem daraus gewonnenen natürlichen Heu. Wiesengras hat in 1 kg Trockensubstanz durchschnittlich 200 bis 300 mg Karotin, Wiesenheu nur noch durchschnittlich 10 bis 20 mg, d. h. bei der Heuwerbung gehen bis zu 90% und mehr des

Karotins verloren. In gut geworbenem Gärfutter und schonend getrocknetem Grünmehl bleibt dagegen der größte Teil des Karotins (etwa 90%) erhalten.

Versuchsanordnung:

Da die größten Karotinverluste bei der natürlichen Heubereitung entstehen, sollte der Einfluß verschiedener Heuwerbungsmethoden auf den Karotingehalt untersucht und zugleich festgestellt werden, in welcher Beziehung der Karotingehalt zu den übrigen Nährstoffen steht.

Die Heuproben entstammen einem im Donaueschinger Institut laufenden Heuwerbungsversuch. Mitgeteilt werden die Ergebnisse der Jahre 1952 und 1953. Die Gegenüberstellung dieser beiden Jahre ist insofern recht aufschlußreich, als das Jahr 1952 ein ausgesprochen trokkenes, das Jahr 1953 ein ausgesprochen nasses Jahr mit Bezug auf die Heuernte waren. Im Jahre 1952 fielen während der Heuernte 4 bis 5 mm Niederschläge, im Jahre 1953 dagegen über 200 mm, an einem Tag allein 88 mm! Das Ausgangsmaterial entstammte einem einheitlichen Wiesenbestand (Hafer-Schwingel-Fuchsschwanz-Knaulgrastyp nach K n o l l [3]) in einer Höhenlage von 670 m NN, der bei normalem 1. Schnitt etwa 150 mg Karotin in 1 kg Grastrockenmasse enthält. Dieses Wiesengras wurde sowohl am Boden als auch auf Gerüsten getrocknet und das Heu auf Nährstoffe und Karotingehalt untersucht. Die Versuchsanordnung weist für beide Jahre 3 Parzellen mit Bodentrocknung, 2 Parzellen mit Heinzen und 1 Parzelle mit Schwedenreutern auf. Jede Parzelle hatte 4 Wiederholungen. Das Heu wurde in Parzelle 1 einmal, in Parzelle 2 zweimal, in Parzelle 3 dreimal gewendet, in Parzelle 4 sofort, in Parzelle 5 nach eintägiger Vortrocknung am Boden auf Heinzen gehängt und in Parzelle 6 sofort auf Schwedenreuter gebracht.

Analysen-Methodik:

Die Nährstoffuntersuchungen erfolgten nach dem Weender Verfahren auf Roheiweiß, Rohfett, Rohfaser, N-freie Extraktstoffe und Rohasche (4), wobei die Rohfaser nach dem abgekürzten Verfahren von L e p p e r bestimmt wurde.

Verdauliches Roheiweiß und Stärkeeinheiten wurden nach den Futterwerttabellen der DLG (1) berechnet. Die Verdaulichkeitswerte für verschiedene Heuqualitätsstufen wurden auf der Basis des Rohfasergehaltes in der Trockensubstanz ausgewählt.

Die Karotinbestimmung im Heu wurde in folgender Modifikation vorgenommen: 5 g feingehäckselte ursprüngliche Heusubstanz wurden in einem 250-ml-Kjeldahlkolben mit 50 ml Petroleumbenzin (Merck) versetzt und 4 Stunden auf dem elektrischen Wasserbad bei 80° C am Rückflußkühler gekocht. Als Rückflußkühler dienten ca. 1 m lange mit Gummistopfen aufgesetzte Glasrohre. Nach der Extraktion wurde auf einer Glasfilternutsche 17 G 3 abgesaugt und die Substanz noch zwei- bis dreimal mit kleinen Mengen Petroleumbenzin bis zur Farblosigkeit des Filtrats nachgewaschen. Das Filtrat wurde über Kalziumchlorid getrocknet, an Aluminiumoxyd (Merck, standard. n. Brockmann) adsorbiert und mit Benzin : Benzol (4:1) eluiert. Die erhaltenen Karotinlosungen wurden im Lange-Kolorimeter gemessen und mit einer Eichkurve verglichen, die mit reinem β-Karotin (Merck) aufgestellt wurde.

Die warme Extraktion nur mit Petroleumbenzin ergab in Vorversuchen gute Übereinstimmung mit der üblichen Alkohol-Benzin-Extraktion (vgl. 2).

Versuchsergebnisse:

Die Ergebnisse der Untersuchungen sind im einzelnen in Tabelle 1 wiedergegeben. Angeführt wurden neben dem Karotin nur das verdauliche Eiweiß und die Stärkeeinheiten.

Im Trockenjahr 1952 weist das Bodenheu relativ gute Karotingehalte von 8, 9 und 11 mg/kg in der Trockensubstanz auf; das Reuterheu liegt aber mit 13, 14 und 17 mg/kg noch erheblich darüber. Im Eiweißgehalt zeigen alle Parzellen-Mittelwerte mit Ausnahme von Parzelle 3 nur geringe Unterschiede. Die Stärkeeinheiten weisen deutlichere Abstufungen auf und stehen in enger Beziehung zu den Karotinwerten. Sprunghafte Unterschiede im Gehalt an Stärkeeinheiten innerhalb der Wiederholungen einer Parzelle sind darauf zurückzuführen, daß entsprechend dem gefundenen Rohfasergehalt verschiedene Verdaulichkeitswerte bei der Berechnung anzuwenden waren. Trotzdem sind die Unterschiede zwischen Boden- und Gerüsttrocknung sehr deutlich, wenn man von Parzelle 3 absieht, die in allen 3 Qualitätsmerkmalen sehr günstig abschneidet und die Qualität des Reuterheues erreicht. Eine einfache Erklärung für diese Ausnahme konnte nicht gefunden werden. Es ist daraus jedoch ersichtlich, daß bei günstigem Erntewetter auch am Boden gute Heuqualitäten gewonnen werden können, die

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Effect of Calcium Hydroxide on the Microflora of Carious Cavities

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In the Soviet and foreign literature there a number of papers devoted to the treatment of inflamed pulp with calcium hydroxide. The majority of the authors (and this coincides with our observations) point out the positive results of such treatment.

In connection with the high pH (8.0 - 10.0) of calcium hydroxide, which creates unfavorable conditions for the vital activity of bacteria, many specialists (Nyborg; Marmasse, and others/ assume that the action of calcium hydroxide is based on its antiseptic effect. Some of them cited data according to which, under the influence of calcium hydroxide, there are destroyed escherichia, typhus salmonella, cholera vibrio, bacillus anthracis, and other bacteria. Others (King and coauthors) have noted that calcium hydroxide acts bactericidally on the microbic flora in the oral cavity. They obtained sterilization of carious dentine, in 61.4% of the cases, while treating with calcium hydroxide. S. V. Makarov carried out a comparative study of the action of a number of therapeutic pastes on the inoculability of microorganisms from a carious cavity and, by investigating the bactericidal activity of pates in vitro, came to the conclusion that a paste with calcium hydroxide retards the growth of microbic flora in carious teeth in 75% of the cases. We found no other papers, with reference to this problem, in the literature that was accessible to us.

We made a study of the microbic flora of carious cavities in the case of 60 patients with an inflamed pulp prior to and subsequent to treatment with calcium hydroxide. For a microbiological study, the material was taken up from the bottom of the carious cavity by means of a sterile excavator and inoculated in a sugar and liver broth with subsequent seeding in dishes with blood, sugar and tomato agar and in a column with a liquefied semifluid liver agar. Following the deposition, at the bottom of the carious cavity, of calcium hydroxide, it was covered with aqueous dentine. The temporary filling was eliminated after 7 days, and once again, material was taken from the bottom of the carious cavity for microbiological study. The latter was carried out in accordance with the procedure described above.

((Table on pg. 76 of text))

Inoculability of Various Representatives of Microbic Flora from Carious Cavities Prior to and Subsequent to Treatment with Calcium Hydroxide

Bacteria Isolated		Prior to Treatment: Amount of Strains			% of Isolation		Subsequent to Treatment: Amount of Strains			% of Isolation
eptococci	alpha	8				alpha	2			
	beta	9				beta	3			
	gamma	27				gamma	19			
		Total. .44			73		Total. 24			40
		Golden	White	Yellow			Golden	White	Yellow	
Staphylococci	alpha	1	-	-		alpha	-	-	-	
	beta	5	1	1		beta	2	2	1	
	gamma	-	14	10		gamma	-	8	4	
		Total... 32			53.3		Total ... 17			25
Lactobacteria	alpha	1				beta	4			
	beta	7				gamma	17			
	gamma	21								
		Total ... 29			48.3		Total .. 21			35
Bacteroids		18			30		13			21.6
Candida		10			16.6		23			38.3
Pneumococci		2			3.3		3			5

((text continued)): Prior to treatment, there were seeded, primarily, steptococci, staphylococci, or their associations with lactobacteria and bacteroids.

The table shows that out of 44 strains of streptococci, 9 yielded beta-hemolysis on a blood agar, 8 -- alpha-hemolysis, and 27 strains grew according to the gamma-hemolysis type. Out of 32 strains of straphylococci, beta-hemolysis on a blood agar was induced by 7; according to the alpha-hemolysis type, there grew 1 strain; and according to the gamma-hemolysis type -- 24. Staphylococci with beta-hemolysis were coagulase-positive and had a vitelline factor (lecithinase). Of them, 5 were golden, 1 -- with a yellow, and 1 -- with a white, pigment. Out of 29 strains of lactobacteria, on a blood agar, 7 yielded beta-hemolysis, 1 -- alpha-hemolysis, and the remainder -- gamma-hemolysis. There were also isolated 10 strains of yeast-type fungi and 2 strains of pneumococci. Following treatment, in the majority of cases, there were isolated yeast-type fungi in association with representatives of coccal flora and with various rod-shaped (staff-form) bacteria. A complete sterilizing effect was observed only in the case of 11 patients (18.3% of the cases).

As may be seen from the table, calcium hydroxide appreciably inhibits the growth, for the main part, of gram-positive cocci and lactobacteria,and also, brings about a reduction in the hemolytic properties of the strains isolated. In particular, there is a reduction in the frequency of disclosure of strains yielding beta-hemolysis on a blood agar. As a result of the growth inhibition of gram-positive flora, which represents an antagonist of yeast-type fungi, the inoculability of the latter increases.

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как правило, не отмечался. У лиц, потреблявших эту воду с детского возраста, когда постоянные зубы находились еще в стадии формирования, флюороз зафиксирован во всех случаях.

Нами установлено, что частота поражения зубов у жителей флюорозного очага кариесом была на 20—30% меньше, чем у населения соседних сел, потреблявшего воду из шахтных колодцев (в этой воде концентрация фтора составляла от 0,5 до 0,7 *мг/л*).

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ВЛИЯНИЕ ГИДРООКИСИ КАЛЬЦИЯ НА МИКРОФЛОРУ КАРИОЗНОЙ ПОЛОСТИ

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В советской и зарубежной литературе есть ряд работ, посвященных лечению воспаленной пульпы гидроокисью кальция. Большинство авторов (это совпадает и с нашими наблюдениями) указывает на положительные результаты такого лечения.

В связи с высоким pH (8,0—10,0) гидроокиси кальция, создающим неблагоприятные условия для жизнедеятельности бактерий, многие специалисты (Nyborg; Marmassé, и др.) предполагают, что действие гидроокиси кальция основано на антисептическом ее эффекте. Некоторые из них приводят данные, согласно которым под влиянием гидроокиси кальция погибают эшерихии, сальмонеллы тифа, холерный вибрион, сибиреязвенная палочка и другие бактерии. Другие (King с соавторами) отмечают, что гидроокись кальция действует бактерицидно на микробную флору полости рта. Они получили стерилизацию кариозного дентина при лечении гидроокисью кальция в 61,4% случаев. С. В. Макаров провел сравнительное изучение действия ряда лечебных паст на высеваемость микроорганизмов из кариозной полости и, исследуя бактерицидную активность паст in vitro, пришел к выводу, что паста с гидроокисью кальция задерживает рост микробной флоры кариозных зубов в 75% случаев. Других работ по этому вопросу в доступной нам литературе мы не нашли.

Мы исследовали микробную флору кариозных полостей у 60 больных с воспаленной пульпой до и после лечения гидроокисью кальция. Для микробиологического исследования материал забирали со дна кариозной полости стерильным экскаватором и засевали в сахарный и печеночный бульон с последующими высевами на чашки с кровяным, сахарным

Высеваемость различных представителей микробной флоры из кариозных полостей до и после лечения гидроокисью кальция

Выделенные бактерии		До лечения: Количество штаммов	До лечения: % выделения		После лечения: Количество штаммов	После лечения: % выделения
Стрептококки	α β γ	8 9 27 Всего . . . 44	73	α β γ	2 3 19 Всего . . . 24	40
Стафилококки	α β γ	Золотистые: 1, 5, — Белые: —, 1, 14 Желтые: —, 1, 10 Всего . . . 32	53,3	α β γ	Золотистые: —, 2, — Белые: —, 2, 8 Желтые: —, 1, 4 Всего . . . 17	25
Лактобактерии	α β γ	1 7 21 Всего . . . 29	48,3	β γ	4 17 Всего . . . 21	35
Бактероиды Candida Пневмококки		18 10 2	30 16,6 3,3		13 23 3	21,6 38,3 5

и томатным агаром и в столбик ра...
наложения на дно кариозной полост...
Временную пломбу удаляли через 7...
лости для микробиологического исс...
методике.

До лечения высевались преим...
циации с лактобактериями и бакте...

Таблица показывает, что из 44 ...
агаре, 8 — α-гемолиз и 27 штаммов ...
β-гемолиз на кровяном агаре вызыва...
молиза — 24. Стафилококки с β-гем...
точный фактор (лецитиназу). Из ни...
пигментом. Из 29 штаммов лактобак...
молиз, остальные — γ-гемолиз. Было...
и 2 штамма пневмококка. После ле...
подобные грибы в ассоциации с пре...
ковидными бактериями. Полный сте...
ных (18,3% случаев).

Как видно из таблицы, гидроо...
разом грамположительных кокков и ...
тических свойств выделенных штамм...
мов, дающих β-гемолиз на кровяном ...
ной флоры, которая является антаго...
них возрастает.

ОПЫТ КОНСЕРВАТИВНО-ХИ... ВЕРХНИХ МОЛЯРОВ

М. И. Крупник

1-я Луганская городская стом...
А. И. Каминская)

Лечить периодонтит верхних мо...
довольно трудно и сохранить такие з...

В литературе сообщается о лече...
стального и удалением медиального ...
каналов (Н. М. Авраменко [1]; И. П. ...

Мы применили консервативно-х...
донтита верхних моляров с непроходи...
(9 женщин и 3 мужчин) в возрасте от...

Показанием для сохранения зуб...
функциональную ценность, зубы был...
и один из щечных корневых каналов...

Методика лечения состоит в сле...
рабатывали проходимые корневые ка...
ных) или резорцин-формалином с пор...

Через 2—4 дня при отсутствии ...
приступали к удалению щечного кор...
ления зависит от расположения карио...
гаются в одной части зуба, алмазным...
ную стенку коронки зуба вместе с н...
вают элеватором или прибегают к а...

В случаях, когда щечный корен...
шенной частью коронки, удаление его...
не устья корневого канала корень о...
удаленным корнем должен быть сдел...
между коронкой и лункой не задерж...
хватывала оба щечных корня. Меди...
$^2/_3$ длины. Медиальный корень удали...

Через 2—5 дней после удалени...
постоянную пломбу. У 7 больных п...

[1] Стоматология, 1956, № 2, ...
[2] Там же, 1966, № 1, с...

и томатным агаром и в столбик расплавленного полужидкого печеночного агара. После наложения на дно кариозной полости гидроокиси кальция ее закрывали водным дентином. Временную пломбу удаляли через 7 дней и повторно брали материал со дна кариозной полости для микробиологического исследования. Последнее проводили по описанной выше методике.

До лечения высевались преимущественно стрептококки, стафилококки или их ассоциации с лактобактериями и бактероидами.

Таблица показывает, что из 44 штаммов стрептококка 9 давали β-гемолиз на кровяном агаре, 8 — α-гемолиз и 27 штаммов росли по типу γ-гемолиза. Из 32 штаммов стафилококка β-гемолиз на кровяном агаре вызывали 7, по типу α-гемолиза рос 1 штамм, а по типу γ-гемолиза — 24. Стафилококки с β-гемолизом были коагулазоположительными и имели желточный фактор (лецитиназу). Из них 5 были золотистыми, 1 — с желтым и 1 — с белым пигментом. Из 29 штаммов лактобактерий на кровяном агаре 7 давали β-гемолиз, 1 — α-гемолиз, остальные — γ-гемолиз. Было выделено также 10 штаммов дрожжеподобных грибов и 2 штамма пневмококка. После лечения в большинстве случаев были выделены дрожжеподобные грибы в ассоциации с представителями кокковой флоры и с различными палочковидными бактериями. Полный стерилизующий эффект мы наблюдали только у 11 больных (18,3% случаев).

Как видно из таблицы, гидроокись кальция значительно подавляет рост главным образом грамположительных кокков и лактобактерий, а также вызывает понижение гемолитических свойств выделенных штаммов. В частности, снижается частота обнаружения штаммов, дающих β-гемолиз на кровяном агаре. В результате подавления роста грамположительной флоры, которая является антагонистом дрожжеподобных грибов, высеваемость последних возрастает.

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ОПЫТ КОНСЕРВАТИВНО-ХИРУРГИЧЕСКОГО ЛЕЧЕНИЯ ПЕРИОДОНТИТА ВЕРХНИХ МОЛЯРОВ

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Лечить периодонтит верхних моляров с непроходимыми щечными корневыми каналами довольно трудно и сохранить такие зубы нередко не представляется возможным.

В литературе сообщается о лечении периодонтита нижних моляров с сохранением дистального и удалением медиального корня при непроходимости его медиальных корневых каналов (Н. М. Авраменко[1]; И. И. Кушнир[2], и др.).

Мы применили консервативно-хирургический метод при лечении хронического периодонтита верхних моляров с непроходимым каналом одного из щечных корней у 12 больных (9 женщин и 3 мужчин) в возрасте от 16 до 57 лет.

Показанием для сохранения зуба являлись случаи, когда коронка зуба представляла функциональную ценность, зубы были устойчивыми, корни их — не сросшимися, небный и один из щечных корневых каналов — проходимыми.

Методика лечения состоит в следующем. После рентгенологического обследования обрабатывали проходимые корневые каналы и пломбировали их фосфатцементом (у 7 больных) или резорцин-формалином с порошком фосфат-цемента (у 5 больных).

Через 2—4 дня при отсутствии осложнений после пломбирования корневых каналов приступали к удалению щечного корня с непроходимым корневым каналом. Методика удаления зависит от расположения кариозной полости и удаляемого корня. Если они располагаются в одной части зуба, алмазным диском и тонким фиссурным бором отпиливают щечную стенку коронки зуба вместе с подлежащим удалению корнем, который затем вывихивают элеватором или прибегают к альвеолэктомии.

В случаях, когда щечный корень с непроходимым каналом расположен над неразрушенной частью коронки, удаление его начинают с альвеолэктомии фиссурным бором на уровне устья корневого канала корень отпиливают от коронки и удаляют. Скос в коронке над удаленным корнем должен быть сделан под углом 45—60°, чтобы после заживления лунки между коронкой и лункой не задерживалась пища. У одного больного кистогранулема захватывала оба щечных корня. Медиальный был непроходим, а дистальный проходим на ⅔ длины. Медиальный корень удалили, а в дистальном резецировали верхушечную часть.

Через 2—5 дней после удаления корня на оставшуюся часть коронки накладывали постоянную пломбу. У 7 больных полости пломбировали пластмассой норакрил, а у 5 —

[1] Стоматология, 1956, № 2, с. 59.
[2] Там же, 1966, № 1, с. 97.

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EPITHELIAL ATYPIA IN HAMSTER CHEEK POUCHES TREATED REPEATEDLY WITH CALCIUM HYDROXIDE

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INVESTIGATORS have been interested for many years in the possibility that some oral cancers develop because of exposures to tobacco and betel quid chews (Friedell and Rosenthal, 1941 ; Orr, 1933). There is sound clinical and epidemiologic evidence that oral cancers are unusually frequent in persons who chew tobacco and "dip" snuff (Moertel and Foss, 1958 ; Sorger and Myrden, 1960 ; Landy and White, 1961 ; Dunn and Farrior, 1962 ; Rosenfeld and Callaway, 1963 ; Brown *et al.*, 1965). These cancers often develop at multiple sites in the mouth. Tobacco has been considered the ingredient of the betel quid most likely to cause changes in the oral mucosa that eventuate in the development of oral cancer (Khanolkar, 1951 ; Sanghvi, Rao and Khanolkar, 1955 ; Shanta and Krishnamurthi, 1963).

It has also been suggested that lime, a weak alkali which is almost always an ingredient of the betel quid, may act as a carcinogen or co-carcinogen (Davis, 1915 ; Orr, 1933 ; Atkinson *et al.*, 1964). Oral cancers are unusually frequent in New Guinea, and though lime is a component of the quid used there, tobacco is never added (Atkinson *et al.*, 1964). Conklin (1958) describes the Hanunóo Filipino native habit of betel chewing and comments in connection with undesirable effects of the chew : "Burning of the inner walls of the mouth and tongue because of an overdosage of lime, makes the mastication of salty foods and certain vegetables very painful." Another ingredient of the betel quid, gambier, which is an extract from the vine *Uncaria gambir*, is a suspected carcinogen by virtue of its tannin content (Korpássy and Mosonyi, 1950 ; Kirby, 1960). In experimental studies Muir and Kirk (1960) have induced cancers in the skin of two of twelve mice at the site of daily painting with an aqueous extract of a typical whole Singapore betel quid. However Dunham and Herrold (1962) could not induce tumors in the hamster cheek pouch treated by beeswax pellets that contained betel quid ingredients from several Asian countries.

In the present report the results are given of long-term exposure of the hamster cheek pouch to three ingredients of the betel quid administered in powdered form namely, calcium hydroxide, a proprietary brand of snuff, and gambier. Cornstarch dusting powder was used as a control.

MATERIALS AND METHODS

Syrian hamsters (*Mesocricetus auratus*) were obtained at weaning from the Animal Production Center of the National Institutes of Health. The hamsters were fed Purina laboratory chow daily and small portions of carrot, apple, and kale three times a week. Drinking water was always available. Initially four to six animals were housed in wire cages but as they grew older they were housed alone to prevent cannibalism of cage-mates that died. There were both males and females in each experimental group.

The calcium hydroxide used was USP $Ca(OH)_2$ powder, Mallinckrodt, St. Louis, U.S.A. The brand "X" snuff was a "Scotch" or dry type prepared in the United States, and was one of two brands habitually used by a woman "snuff-dipper" who died as a result of multicentric oral cancer. The snuff was aromatic, but it is not known what the additives were, since snuffs are prepared by secret formulas. Cake gambier, obtained in Singapore, was ground to powder in a Waring Blendor. We used a cornstarch derivative dusting powder as a control material. This was a "Non-peptizable homogeneous mixture of amylose and amylopectin derived from cornstarch, together with 2 per cent magnesium oxide."

TABLE I.—*Survey of Experimental Groups of Hamsters, their Average Age, the Percentage Frequency of Cheek Pouch Lesions and the Incidental Tumours*

Group*	Number in group	Average age in weeks	Percent with pouch lesions	Incidental tumours
I. Gambier alone	14	73	14	Lymphoma, bowel cancer, melanoma
II. Snuff alone	7	99	—	2 with bowel cancer
III. Starch powder alone	4	78	—	——
IV. $Ca(OH)_2$ alone†	6	81	100	2 with bowel cancer
V. Equal parts $Ca(OH)_2$ and gambier†	5	98	40	2 with lymphoma
VI. Equal parts $Ca(OH)_2$ and snuff	6	77	100	——
VII. $Ca(OH)_2$ in a.m., snuff in p.m.	6	67	100	——
VIII. $Ca(OH)_2$ in a.m., cornstarch in p.m.	6	88	100	Granulosa cell tumour of ovary

* Animals in the first five groups received 250 mg. at each application for the first two weeks of the experiment.

† Treatments were reduced to 3 times each week between the second and 40th weeks of treatment.

There were eight groups of hamsters (Table I). Each of the four powdered substances (groups I to IV) and mixtures of equal parts of calcium hydroxide and gambier or snuff (groups V and VI) was administered for five consecutive days each week. Hamsters in groups VII and VIII were treated twice daily for five days each week. Hamsters in both these groups received calcium hydroxide in the morning, and three to five hours later in the afternoon, animals in group VII received snuff and animals in group VIII received cornstarch powder. A Vienna nasal speculum, child's size, was used to apply about 50 mg. of the test material at each treatment. The half-filled instrument was inserted deep in the right cheek pouch, the blades were opened, and the powder was distributed to the fundus and walls of the pouch and the inner surface of the lip. Thus both the pouch epithelium, which is similar to that lining the oral cavity but without accessory structures, and a part of the oral cavity were exposed to the powdered materials. A relatively prolonged contact is maintained in the cheek pouch. The powders were found plastered against its walls as long as six hours after application.

Treatment was started when the hamsters were three and a half to four and a half weeks old. They lived out their life spans and were either killed when moribund, or were found dead. Complete post mortem examinations were performed, tissues were fixed in buffered 10 per cent formalin, embedded in paraffin, and cut at 6 μ. Sections were stained routinely with haematoxylin and eosin, and treated by the von Kossa method to demonstrate calcium.

RESULTS

The pouches of 26 of the 29 hamsters treated with calcium hydroxide, either alone or in combination, showed gross changes (groups IV to VIII). The initial alkaline burn sometimes healed partially or completely between treatments, especially during the weekends when treatment was stopped, and in the early weeks of the experiment. Lesions were often multifocal and developed most often in the proximal third of the pouch, but were not restricted to this area. Chronically damaged pouches were inflamed and thickened and exhibited bleeding points, shallow ulcers, abscesses, or scars that resulted in puckering of the pouch wall and sometimes led to sloughing of tissues and a shortened pouch. In some instances portions of the pouch wall appeared to be nodular, and in others thin crusts covered some of the lesions. Occasionally the mucosal surface of the lip was grossly inflamed. A fundal scar was noted in the pouch of one hamster treated with gambier. There were no changes in the pouches of hamsters treated with snuff alone or with starch powder alone (Table I).

Microscopic examination of tissue from pouches of the 26 affected hamsters treated with calcium hydroxide revealed one or more of the following lesions in the lamina propria : deposits of calcium, infiltration of inflammatory cells, giant cells, and fibroblastic proliferation (Fig. 1 to 4). The various lesions noted in the

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EXPLANATION OF PLATES

FIG. 1.—Cheek pouch of hamster treated with calcium hydroxide for 81 weeks. Lesions were multifocal. The epithelium at the edge of a small ulcer is atrophic. Chronic inflammatory cells are scattered throughout the lamina propria, where a single darkstaining deposit of calcium is seen. H. and E. ×205.

FIG. 2.—Cheek pouch of hamster treated with equal parts of calcium hydroxide and brand "X" snuff for 74 weeks. The epithelium is atrophic. There is no cellular reaction about the clumped deposits of calcium situated deep in the lamina propria. H. and E. ×80.

FIG. 3.—Biopsy of a multifocal inflamed nodular lesion that developed in the cheek pouch of a hamster treated with calcium hydroxide for 42 weeks (life, 61 weeks). The epithelium shows hyperplasia, hyperkeratosis and acanthosis. The underlying connective tissue exhibits fibrosis, a deposit of calcium and giant cells. H. and E. ×170.

FIG. 4.—Cheek pouch of hamster treated with calcium hydroxide in the morning and brand "X" snuff in the afternoon for 81 weeks. Lesions were multifocal. Hyperkeratosis, acanthosis, rete peg formation and basal cell hyperplasia are seen in the epithelium, and there is a multinucleated giant cell in the lamina propria (arrow). H. and E. ×200.

FIG. 5.—Cheek pouch of hamster treated with calcium hydroxide in the morning and corn-starch powder in the afternoon, for 102 weeks. The thickened pouch wall shows epithelial hyperplasia, hyperkeratosis, acanthosis and rete peg formation. H. and E. ×135.

FIG. 6.—Another area of the cheek pouch shown in Fig. 1, treated with calcium hydroxide. This is a focus of epithelial hyperplasia, parakeratosis and cellular atypia. Note the loss of polarity, hyperchromatism and disturbed basal cell layer. H. and E. ×205.

FIG. 7.—Cheek pouch of hamster treated with equal parts of calcium hydroxide and gambier for 121 weeks. Lesions were multifocal. Atypical cells show loss of polarity, and some basal cells are fusiform. H. and E. ×205.

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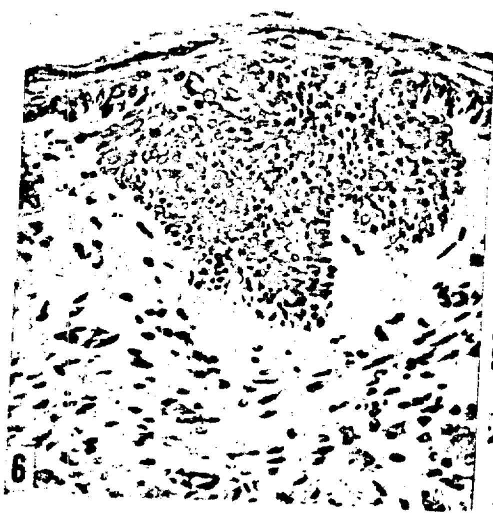

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epithelium were ulceration, foci of inflammatory cells, atrophy or hyperplasia, hyperkeratosis, parakeratosis, acanthosis, and cellular atypia (Fig. 1 to 7). The lesion illustrated in Fig. 2 probably followed a small ulcer that permitted the entry of calcium to the lamina propria; after healing the calcific deposit was covered by atrophic epithelium. Hyperplasia, shown by increased thickness of the epithelium, and rete pegs (Fig. 4 and 5) are not normally seen in the hamster pouch. The lesions most suggestive of a pre-neoplastic condition were small foci of atypical cells (Fig. 6 and 7) which showed loss of cellular polarity, and cells in the basal layer that were hyperchromatic and fusiform.

The tongue of a hamster that received calcium hydroxide in the morning and snuff in the afternoon showed the usual features of a chemical burn, i.e. a large ulcer, epithelial atrophy, homogenized collagen in the lamina propria, chronic inflammatory infiltrate, and necrosis of some of the muscle bundles. Enlarged submaxillary lymph nodes in four hamsters were hyperplastic on microscopic examination. Three of the hamsters had been treated with lime, and one with cornstarch powder. The forestomachs of the animals that had received calcium hydroxide alone or in combination were usually normal, though two showed slight hyperkeratosis and epithelial hyperplasia. In comparison with the calcium hydroxide, the other substances caused little damage. Microscopic lesions at single foci in the pouches of 2 of the 14 hamsters treated with gambier were focal infiltration of inflammatory cells in one instance and a minute ulcer in the other. Focal inflammation was seen also in the outer lips of two hamsters treated with gambier. A polyp of the forestomach that developed in a hamster treated with gambier alone was probably spontaneous, and the glandular stomachs and other organs of the hamsters in the experiment were within normal limits. The types and distribution of the incidental tumours that developed in hamsters in five of the experimental groups (Table I) resemble the spontaneous tumors of hamsters described by Dunham and Herrold (1962).

DISCUSSION

In the present study calcium hydroxide apparently entered the cheek pouch wall through a break in its surface and calcium accumulated deep in the connective tissue. There was little cellular reaction to the clumped deposits of calcium. Oppenheim (1935) treated the skin of a rabbit with calcium chloride and has published a microphotograph showing masses of calcium in the lamina propria and epithelial acanthosis. It is of interest that one of the authors (J.E.H.) observed calcium deposits in the connective tissue beneath a squamous cell carcinoma of the buccal mucosa in a Vietnamese female betel quid chewer (Armed Forces Institute of Pathology, accession No. 1181731). Betel quids usually contain calcium hydroxide. The deposits below the cancerous epithelium resembled those seen in hamster pouches treated with lime, though they were comparatively small and scattered.

At least three of the lesions in the pouch epithelium produced by repeated applications of calcium hydroxide progressed to distinct cellular atypia. The lesions resembled oral dyskeratosis (leukoplakia) in man (Waldron and Shafer, 1960; Shafer and Waldron, 1961; Shklar, 1965), except that they were focal, and did not widely involve the cheek pouch in any instance. We did not consider that these lesions were pre-invasive cancer.

Carcinogenesis in the cheek pouch of hamsters by painting with 7,12-dimethylbenz(*a*)anthracene (DMBA) proceeds through inflammatory, degenerative, regenerative and hyperplastic phases (Salley, 1954 ; Morris, 1961 ; Hamner, 1966). The similar lesions produced by calcium hydroxide progressed only to the beginning of the hyperplastic phase. The treated hamsters lived to the normal or nearly normal extent of their life spans. It cannot be ascertained from this experiment whether the lesions that developed were the final phase of the reaction to the treatment with calcium hydroxide, or whether they had the potential of progression to neoplasia. To assist in answering these questions calcium hydroxide is being applied to pouches using a wetting agent as vehicle, and pouches of hamsters maintained on a modified diet are being treated with calcium hydroxide.

Oral cancers are relatively frequent in betel quid chewers. The relationship of these cancers to the lime or calcium hydroxide that is added to the quids is uncertain. Perhaps damage such as is produced in the hamster pouch by repeated applications of calcium hydroxide renders the affected area more susceptible to the effects of a carcinogen. It is known that oesophageal cancer sometimes develops long after oesophageal stricture resulting from burns due to the ingestion of sodium hydroxide (lye) (Delph, 1937 ; Bigger and Vinson, 1950). Reports from Iran suggest that cancer of the oesophagus is related to the habit of chewing *nass* (Azarmie, 1965, personal communication ; Rahmatian, 1965). The ingredients of *nass* are lime, tobacco, and wood chips or wood ash. It has been postulated that similar environmental factors may predispose to cancers of the mouth, oesophagus, and tissues of the upper gastrointestinal tract in general (Goodner and Watson, 1956 ; Steiner, 1956).

The observation in the present experiment that powdered tobacco (snuff) did not produce lesions in the hamster cheek pouch does not prove that tobaccos cannot cause injury of the human buccal mucosa that sometimes results in oral cancer. There is no sound experimental proof that tobaccos induce cancer in the mouth, yet it is well recognized that this cancer develops with unusual frequency in " snuff-dippers " and in persons who chew tobacco.

SUMMARY

Repeated applications of calcium hydroxide (lime) severely injured the hamster cheek pouch. Three of the inflammatory and hyperplastic lesions that developed in the pouches of 26 treated hamsters progressed to epithelial atypia. Powdered tobacco (snuff) did not alone produce lesions, and a dusting powder (cornstarch derivative) did not produce lesions. Inflammatory lesions that developed in 2 of 14 pouches treated with gambier were minimal. The effects of calcium hydroxide were not enhanced when snuff was applied in a mixture with the calcium hydroxide or when snuff or cornstarch powder was applied several hours after treatment with calcium hydroxide.

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and continue the titration to a blue end-point. Each ml. of 0.05 *M* disodium ethylenediaminetetraacetate is equivalent to 10.51 mg. of $C_3H_7CaO_6P$.

Alkalinity. A solution of 1 gram in 60 ml. of water requires not more than 1.5 ml. of 0.1 *N* sulfuric acid for neutralization, using 3 drops of phenolphthalein T.S. as indicator.

Arsenic. A *Sample Solution* prepared as directed for organic compounds meets the requirements of the *Arsenic Test*, page 720.

Heavy metals. Dissolve 500 mg. in 3 ml. of diluted acetic acid T.S., and dilute to 25 ml. with water. This solution meets the requirements of the *Heavy Metals Test*, page 763, using 20 mcg. of lead ion (Pb) in the control (*Solution A*).

Lead. A *Sample Solution* prepared as directed for organic compounds meets the requirements of the *Lead Limit Test*, page 772, using 10 mcg. of lead ion (Pb) in the control.

Loss on drying, page 714. Dry at 150° for 4 hours.

Packaging and storage. Store in tight containers.

Functional use in foods. Nutrient; dietary supplement.

CALCIUM HYDROXIDE

Slaked Lime

$Ca(OH)_2$

Mol. wt. 74.09

DESCRIPTION

A white powder, possessing an alkaline, slightly bitter taste. One gram dissolves in 630 ml. of water at 25°, and in 1300 ml. of boiling water. It is soluble in glycerin and in a saturated solution of sucrose, but is insoluble in alcohol.

IDENTIFICATION

A. When mixed with from 3 to 4 times its weight of water, it forms a smooth magma. The clear, supernatant liquid from the magma is alkaline to litmus.

B. Mix 1 gram with 20 ml. of water, and add sufficient acetic acid to effect solution. The resulting solution gives positive tests for *Calcium*, page 769.

SPECIFICATIONS

Assay. Not less than 95 per cent of $Ca(OH)_2$.

Limits of Impurities

Acid-insoluble substances. Not more than 1 per cent.
Arsenic (as As). Not more than 3 parts per million (0.0003 per cent).
Fluoride. Not more than 50 parts per million (0.005 per cent).
Heavy metals (as Pb). Not more than 40 parts per million (0.004 per cent).
Lead. Not more than 10 parts per million (0.001 per cent).
Magnesium and alkali salts. Not more than 4.8 per cent.

TESTS

Assay. Weigh accurately about 1.5 grams, transfer to a beaker, and gradually add 30 ml. of diluted hydrochloric acid T.S. When solution is complete, transfer it to a 500-ml. volumetric flask, rinse the beaker thoroughly, adding the rinsings to the flask, dilute with water to volume, and mix. Transfer 50.0 ml. of this solution into a suitable container, and add 50 ml. of water. While stirring, preferably with a magnetic stirrer, add about 30 ml. of 0.05 *M* disodium ethylenediaminetetraacetate from a 50-ml. buret, then add 15 ml. of sodium hydroxide T.S. and 300 mg. of hydroxy naphthol blue indicator, and continue the titration to a blue end-point. Each ml. of 0.05 *M* disodium ethylenediaminetetraacetate is equivalent to 3.705 mg. of $Ca(OH)_2$.

Acid-insoluble substances. Dissolve 2 grams in 30 ml. of dilute hydrochloric acid (1 in 3), and heat to boiling. Filter the mixture, wash the residue with hot water, and ignite. The weight of the residue does not exceed 20 mg.

Arsenic. A solution of 1 gram in 15 ml. of diluted hydrochloric acid T.S. meets the requirements of the *Arsenic Test*, page 720.

Fluoride. Weigh accurately 1.0 gram, and proceed as directed in the *Fluoride Limit Test*, page 762.

Heavy metals. Dissolve 500 mg. in 10 ml. of diluted hydrochloric acid T.S., and evaporate to dryness on a steam bath. Dissolve the residue in 25 ml. of water, and filter. The filtrate meets the requirements of the *Heavy Metals Test*, page 763, using 20 mcg. of lead ion (Pb) in the control (*Solution A*).

Lead. A solution of 1 gram in 15 ml. of diluted hydrochloric acid T.S. meets the requirements of the *Lead Limit Test*, page 772, using 10 mcg. of lead ion (Pb) in the control.

Magnesium and alkali salts. Dissolve 500 mg. in a mixture of 30 ml. of water and 10 ml. of diluted hydrochloric acid T.S., and boil for 1 minute. Rapidly add 40 ml. of oxalic acid T.S., and stir vigorously until precipitation is well established. Immediately add 2 drops of methyl red T.S., then add ammonia T.S., dropwise, until the mixture is just alkaline, and cool. Transfer the mixture to a 100-ml. cylinder, dilute with water to 100 ml., let it stand for 4 hours or overnight, then decant the clear, supernatant liquid through a dry filter paper. To 50 ml. of the clear filtrate in a platinum dish add 0.5 ml. of sulfuric acid, and evaporate the mixture on a steam bath to a small volume. Carefully evaporate the remaining liquid to dryness over a free flame, and continue heating until the ammonium salts have been completely decomposed and volatilized. Finally, ignite the residue to constant weight. The weight of the residue does not exceed 12 mg.

Packaging and storage. Store in tight containers.

Functional use in foods. Miscellaneous and general purpose; buffer; neutralizing agent.

~~CALCIUM IODATE~~

$Ca(IO_3)_2.H_2O$ Mol. wt. 407.90

DESCRIPTION

A white powder. It is odorless or has a slight odor. It is slightly soluble in water, and is insoluble in alcohol.

IDENTIFICATION

To 5 ml. of a saturated solution of the sample add 1 drop of starch T.S. and a few drops of 20 per cent hypophosphorous acid. A transient blue color appears.

SPECIFICATIONS

Assay. Not less than 99 per cent and not more than the equivalent of 101 per cent of $Ca(IO_3)_2.H_2O$.

Limits of Impurities

Arsenic (as As). Not more than 3 parts per million (0.0003 per cent).
Heavy metals (as Pb). Not more than 10 parts per million (0.001 per cent).

TESTS

Assay. Weigh accurately about 600 mg., dissolve it in 10 ml. of 70 per cent perchloric acid and 10 ml. of water, heating gently if necessary, and dilute with water to 250.0 ml. Transfer 50.0 ml. to a 250-ml. glass-stoppered Erlenmeyer flask, add 1 ml. of 70 per cent perchloric acid and 5 grams of potassium iodide, stopper the flask, and swirl briefly. Let stand for 5 minutes, then titrate with 0.1 *N* sodium thiosulfate, adding starch T.S. just before the end-point is reached. Each ml. of 0.1 *N* sodium thiosulfate is equivalent to 33.98 mg. of $Ca(IO_3)_2.H_2O$.

Arsenic. Mix 3 ml. of hydrochloric acid with a 1-gram sample, evaporate to dryness on an asbestos board on a hot plate, and cool. Add 5 ml. of hydrochloric acid and again evaporate to dryness. Dis-

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CALCIUM OXIDE

Lime

CaO Mol. wt. 56.08

DESCRIPTION

Hard, white or grayish white masses or granules, or a white to grayish white powder. It is odorless. One gram dissolves in about 840 ml. of water at 25°, and in about 1740 ml. of boiling water. It is soluble in glycerin, but is insoluble in alcohol.

IDENTIFICATION

Slake 1 gram with 20 ml. of water, and add acetic acid until the sample is dissolved. The resulting solution gives positive tests for *Calcium*, page 769.

SPECIFICATIONS

Assay. Not less than 95 per cent of CaO after ignition.

Limits of Impurities

Acid-insoluble substances. Not more than 1 per cent.
Alkalies or magnesium. Not more than 3.6 per cent.
Arsenic (as As). Not more than 3 parts per million (0.0003 per cent).
Fluoride. Not more than 50 parts per million (0.005 per cent).
Heavy metals (as Pb). Not more than 40 parts per million (0.004 per cent).
Lead. Not more than 10 parts per million (0.001 per cent).
Loss on ignition. Not more than 10 per cent.

TESTS

Assay. Ignite about 1 gram to constant weight, and dissolve the ignited sample, accurately weighed, in 20 ml. of diluted hydrochloric acid T.S. Cool the solution, dilute with water to 500.0 ml., and mix. Pipet 50.0 ml. of this solution into a suitable container, and add 50 ml. of water. While stirring, preferably with a magnetic stirrer, add about 30 ml. of 0.05 *M* disodium ethylenediaminetetraacetate from a 50-ml. buret, then add 15 ml. of sodium hydroxide T.S. and 300 mg. of hydroxy naphthol blue indicator, and continue the titration to a blue end-point. Each ml. of 0.05 *M* disodium ethylenediaminetetraacetate is equivalent to 2.804 mg. of CaO.

Acid-insoluble substances. Slake a 5-gram sample, then mix it with 100 ml. of water and sufficient hydrochloric acid, added dropwise, to effect solution. Boil the solution, cool, add hydrochloric acid, if necessary, to make the solution distinctly acid, and filter through a

[illegible] Wash the residue with water until free of chlorides, dry at 105° for 1 hour, cool, and weigh.

Alkalies or magnesium. Dissolve 500 mg. in 30 ml. of water and 15 ml. of diluted hydrochloric acid T.S. Heat the solution and boil for 1 minute. Add rapidly 40 ml. of oxalic acid T.S., and stir vigorously. Add 2 drops of methyl red T.S., and neutralize the solution with ammonia T.S. to precipitate the calcium completely. Heat the mixture on a steam bath for 1 hour, cool, dilute to 100 ml. with water, mix well, and filter. To 50 ml. of the filtrate add 0.5 ml. of sulfuric acid, then evaporate to dryness and ignite to constant weight in a tared platinum crucible.

Arsenic. A solution of 1 gram in 15 ml. of diluted hydrochloric acid T.S. meets the requirements of the *Arsenic Test*, page 720.

Fluoride. Weigh accurately 1.0 gram, and proceed as directed in the *Fluoride Limit Test*, page 762.

Heavy metals. Mix 2 grams with 25 ml. of water, cautiously add 7 ml. of hydrochloric acid, followed by 3 ml. of nitric acid, and evaporate to dryness on a steam bath Dissolve the residue in 1 ml. of diluted hydrochloric acid T.S. and 25 ml. of hot water, filter, wash with a few ml. of water, and dilute the filtrate to 100 ml. with water. A 25-ml. portion of this solution meets the requirements of the *Heavy Metals Test*, page 763, using 20 mcg. of lead ion (Pb) in the control (*Solution A*).

Lead. A solution of 1 gram in 15 ml. of diluted hydrochloric acid T.S. meets the requirements of the *Lead Limit Test*, page 772, using 10 mcg. of lead ion (Pb) in the control.

Loss on ignition. Ignite 1 gram to constant weight in a tared platinum crucible with a blast lamp.

Packaging and storage. Store in tight containers.

Functional use in foods. Alkali; nutrient.

~~CALCIUM PANTOTHENATE~~

Dextro Calcium Pantothenate

$[HOCH_2C(CH_3)_2CH(OH)CONH(CH_2)_2COO]_2Ca$

$C_{18}H_{32}CaN_2O_{10}$ Mol. wt. 476.5

DESCRIPTION

The calcium salt of the dextrorotatory isomer of pantothenic ac occurs as a slightly hygroscopic, white powder. It is odorless and has bitter taste. It is stable in air. One gram dissolves in about 3 ml.

RESEARCH

A HISTOPATHOLOGIC STUDY OF NERVE SCLEROSANTS*

Allen Jesse Koslin, D.D.S., Birmingham, Ala.

INTRODUCTION

The aim of this study was to compare the histopathologic effects of absolute alcohol, Sylnasol,[1-3] and several other agents with potential local neurotoxic action, using the sciatic nerve of the rabbit as the test site. N/10 saline was selected as a control because it does not damage either muscle or nerve tissue.[4] Absolute alcohol has been employed as a neural sclerosant for approximately fifty-five years.[5] In recent years, 5 per cent sodium psylliate with 2 per cent benzyl alcohol (Sylnasol) has been used successfully as a nerve sclerosant and has been thought to be more self-limiting than absolute alcohol. Following the administration of calcium penicillin, sciatic nerve necrosis has been reported.[6] Supersaturated solutions of calcium hydroxide have been used for pulp-capping in clinical dentistry without destroying the dental pulp. Two per cent sodium dicetyl phosphate has produced intense fibroplastic reactions in animal experiments.[7]

METHOD

The agents tested were Sylnasol, 0.2 per cent sodium dicetyl phosphate suspension in olive oil, absolute alcohol, supersaturated solution of calcium hydroxide with a pH of 12.9, calcium penicillin 200,000 units per cubic centimeter with a pH of 6.2, and N/10 saline.

The "Dutch" breed rabbit was used as the experimental animal.

The fascial sheet covering the sciatic nerve was exposed, a 22-gauge needle on a 1 c.c. tuberculin syringe was passed through a small opening in the fascial sheet, and 0.25 c.c. of the desired agent was deposited with minimal pressure around the sciatic nerve. The site of deposition of the agents was the bifurcation of the sciatic nerve to form the peroneal and tibial nerves. The procedure was carried out in a manner designed to avoid mechanical irritation to the nerve.

From the University of Alabama School of Dentistry.

*A research project completed under the auspices of the Department of Oral Surgery. State University of Iowa.

Both sciatic nerves of each rabbit were utilized, with a different agent tested on each side.

Repeated needle pricks on the sole and dorsum of the foot, as a test for anesthesia, produced markedly inconsistent results. Clinical anesthesia was not practically demonstrable.

The animals were sacrificed one, two, three, four, six, eight, ten, and twelve weeks postoperatively. Two series of animals were used for each agent.

The thighs were biopsied and three sections, 4 mm. in thickness, were removed from each thigh as follows:

1. A proximal section near the head of the femur.
2. A central section at the site of deposition of the test agent.
3. A distal section near the distal end of the femur.

The specimen sections were stained with hematoxylin and eosin in accordance with accepted histopathologic techniques. One series for each agent was also stained with Luxol fast blue myelin stain.[8] The specimens were cut 7 microns in thickness, and microscopic slides were prepared. All slides were read at magnifications of ×28, ×100, and ×430.

RESULTS

All specimens in the series in which N/10 saline was the test agent showed no evidence of tissue damage or inflammatory response and were used as the controls (Figs. 1 and 2).

Sylnasol, in one-week specimens, produced a complete loss of axis cylinders and severe demyelinization of the nerve with no visible damage to the Schwann cells (Fig. 3). Muscle and fat damage was mild, with marked early muscle regeneration present. There was an exuberant early histiocytic and chronic inflammatory cell reaction without giant cells or phagocytosis (Fig. 4).

In the two-week specimens the intensity of the histiocytic reaction was reduced, the muscle and fat reaction was similar to the one-week specimens, and early granulation tissue was proliferating.

Complete nerve degeneration remained in the three-week specimens. The muscle and fat appeared to be almost normal. There was an abundance of giant cells with an otherwise scanty chronic inflammatory response.

The four-week specimens exhibited only focal nerve degeneration, most marked in the outer portions of the nerve fascicles. The adjacent tissues appeared to be entirely normal.

The six-, eight-, ten-, and twelve-week specimens appeared to be entirely normal in all respects, with the exception of one twelve-week series which showed a foreign body reaction and focal scarring in the perineural tissues. These latter findings may be attributed to greater initial damage or to an unknown injury sustained by the animal.

The agent did not exhibit a tendency to localize but, rather, spread along the fascial planes that were in association with the nerves.

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Fig. 1.

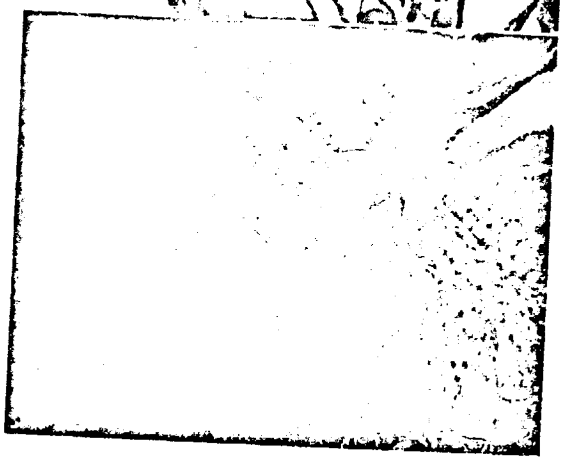


Fig 2.

Fig. 1.—Photomicrograph of N/10 saline specimen at one week. Dense dark-staining nerves are the result of the uptake of stain by myelin and axis cylinders. (Luxol blue stain. Magnification, ×60; reduced 1/6.)

Fig. 2.—Photomicrograph of N/10 saline specimen at one week. There is no damage or tissue response present. (Hematoxylin and eosin stain. Magnification, ×60; reduced 1/6.)

Fig. 3.

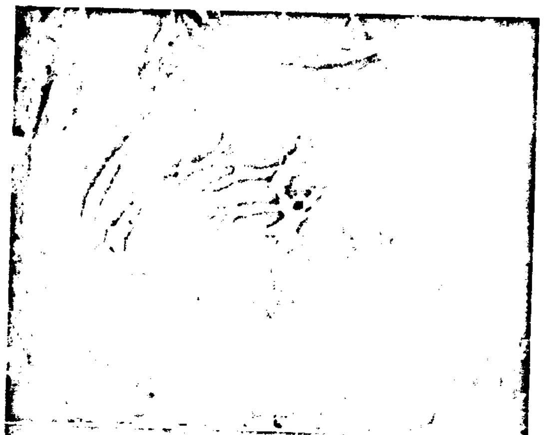


Fig. 4.

Fig. 3.—Photomicrograph of Sylnasol specimen at one week. Marked demyelinization is present, particularly in cross section. (Luxol blue stain. Magnification, ×120; reduced 1/6.)

Fig. 4.—Photomicrograph of Sylnasol specimen at one week. Exuberant histiocytic response and early marginal muscle regeneration are the most prominent features. (Hematoxylin and eosin stain. Magnification, ×60; reduced 1/6.)

Sodium dicetyl phosphate produced no evidence of nerve damage in any of the specimens (Fig. 5). Minimal marginal muscle degeneration and regeneration were present in the one-, two-, and three-week specimens. Even in the one-week specimens, the central sections showed a massive large giant-cell reaction with an extensive chronic inflammatory response (Fig. 6). This

Fig. 5.

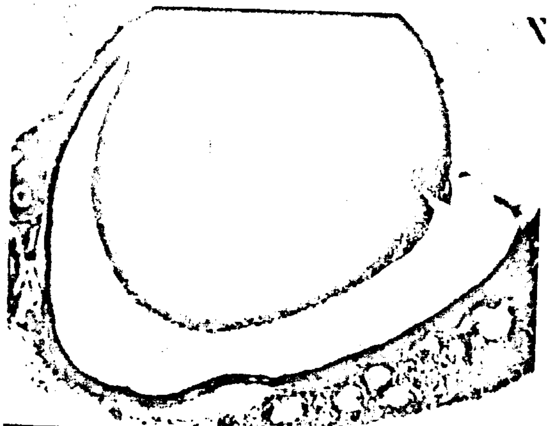


Fig. 6.

Fig. 5.—Photomicrograph of sodium dicetyl phosphate specimen at one week. Myelin and axis cylinders are normal. (Luxol blue stain. Magnification, X60; reduced ⅙.)

Fig. 6.—Photomicrograph of sodium dicetyl phosphate specimen at one week. There are a marked histiocytic response, very large giant cells, and an abundance of fibroblasts. (Hematoxylin and eosin stain. Magnification, X120; reduced ⅙.)

persisted, apparently unchanged, until the sixth week. The six-week specimens showed a diminution in the response. The chronic inflammatory cell proliferation was absent at ten weeks. The giant-cell reaction persisted through ten weeks but was absent in the twelve-week specimens.

Marked fibroblastic activity was present in the one-week specimens and continued through six weeks. Fibrosis was also apparent at one week, increased and matured through four weeks, and showed early cicatrization at six weeks. A moderate amount of cicatrix was present in the perineural fat and connective tissue in the twelve-week specimens.

The agent showed a strong tendency to localize, probably because of its viscosity, at the site of deposition.

Saturated calcium hydroxide solution, in the one-week specimens (Fig. 7), produced an outright focal coagulation necrosis without liquefaction of the nerve, affecting the axis cylinders, myelin sheath, and Schwann cells. These changes were severe. The agent showed a tendency to spread longitudinally along the fascial planes, producing a necrosis in the majority of the proximal sections. The distal sections, less directly affected, showed degeneration of the nerve with demyelinization, approximately fifty per cent loss of the axis cylinders and intact Schwann cells.

There were marked marginal muscle destruction and abundant early muscle regeneration. The fat and connective tissue had undergone an aseptic necrosis. An intense chronic inflammatory response, with many macrophages, separated the damaged from the normal tissues. There was an increase in nerve vascularity, as well as early organization of the necrotic tissue with early fibrosis (Fig. 8).

In the two-week specimens the nerve damage was equally severe, the chronic inflammatory proliferation was less intense, and the proliferation of granulation tissue was more abundant.

The three-week specimens were essentially similar to those at two weeks, with a slight increase in fibrosis and a questionable distortion of the perineurium.

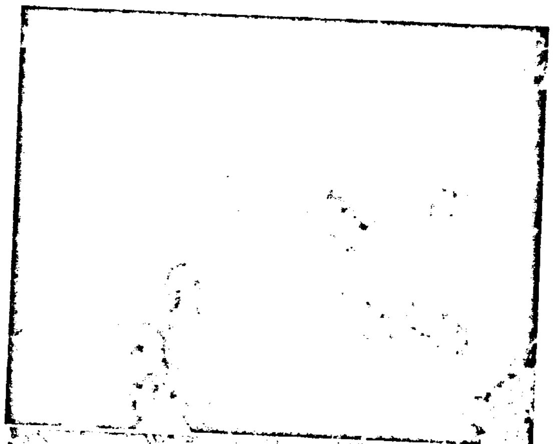
The four-week specimens showed less nerve destruction in the proximal and distal sections, but at the site of injection it was equal to that of the preceding specimens. The perineurium was distorted and showed proliferation of granulation tissue. There was a general increase in the amount of granulation tissue, the fibrosis was maturing, and the scarring was intense. A granular precipitate of calcium was detectable, and giant cells were seen for the first time in this series.

The six-week specimens appeared to represent the beginning of a clean-up process. The nerve showed focal demyelinization, patchy loss, and swelling of axis cylinders and Schwann cells. The chronic inflammatory reaction was focal and minor in intensity. The granulation tissue response was lessened, and the scarring was increased. No further muscle destruction was evident, and many small young muscle fibers were present.

The eight-week specimens showed less demyelinization, very little axis cylinder loss, and intact perineurium, clumps of snarled Schwann cells, and axis cylinders running in haphazard arrangement with many entering into neighboring fascicles. The inflammatory response was absent, the scar shrinking and the muscles completely regenerated.

The ten-week specimens appeared to have complete healing, and all tissues were normal.

Fig. 7.



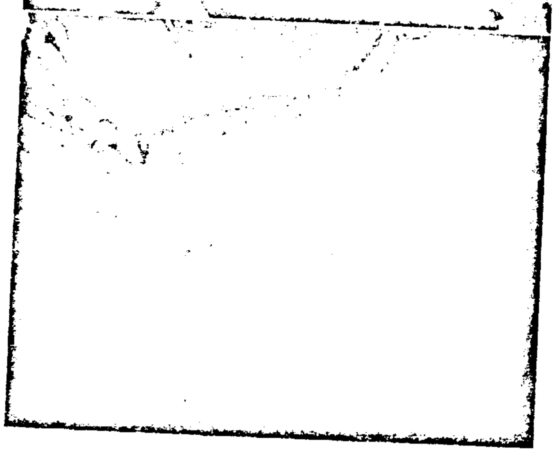


Fig. 8

Fig. 7.—Photomicrograph of calcium hydroxide specimen at one week. There is marked demyelinization and a loss of approximately 50 per cent of the axis cylinders. (Luxol blue stain. Magnification, ×360; reduced 1/6.)

Fig. 8.—Photomicrograph of calcium hydroxide specimen at one week. An area demonstrating the severe muscle degeneration and necrosis. (Hematoxylin and eosin stain. Magnification, ×60; reduced 1/6.)

The twelve-week specimens were similar to those at ten weeks with the exception of one series which more closely resembled the response at six to eight weeks, probably as a result of greater initial damage than in the other specimens.

No vessel damage or thrombosis was noted in this series.

Calcium penicillin produced no visible nerve changes in its entire series (Fig. 9).

Fig. 9.

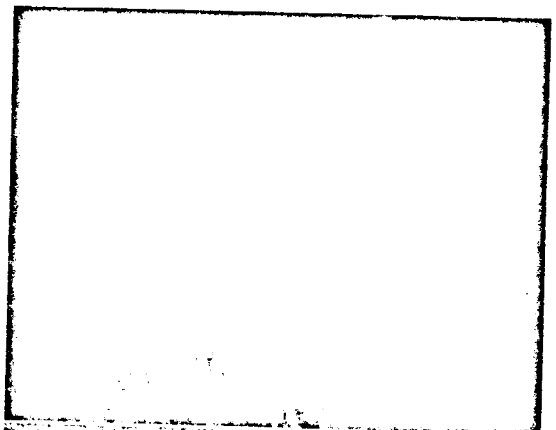


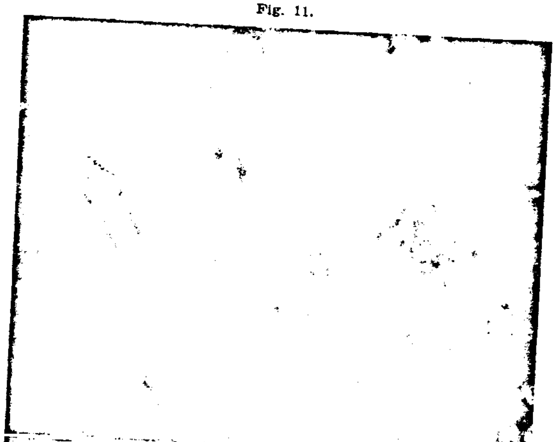
Fig. 10.

Fig. 9.—Photomicrograph of calcium penicillin specimen at one week. Nerve fibers are normal with intact myelin and axis cylinders. (Luxol blue stain. Magnification, ×360; reduced 1/6.)

Fig. 10.—Photomicrograph of calcium penicillin specimen at one week. Marked foreign body reaction with muscle destruction and calcium granules. (Hematoxylin and eosin stain. Magnification, ×60; reduced 1/6.)

An intense foreign body reaction was elicited from the first (Fig. 10) to third weeks, and by the fourth week it was decreasing in intensity. The eight-week specimens showed no inflammatory response. Marginal muscle necrosis

Fig. 11.



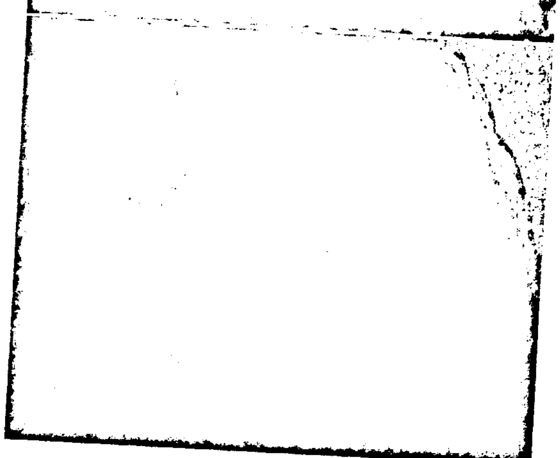


Fig. 12.

Fig. 11.—Photomicrograph of absolute alcohol specimen at one week. The nerve shows demyelinization and loss of axis cylinders. (Luxol blue stain. Magnification, ×360; reduced ⅛.)

Fig. 12.—Photomicrograph of absolute alcohol specimen at one week. There is marginal muscle destruction as well as a mild chronic inflammatory response separating the normal and damaged muscle. (Hematoxylin and eosin stain. Magnification, ×60; reduced ⅛.)

was present for two to three weeks, with some regeneration occurring. A marked fibroblastic response, beginning in the first week, produced large amounts of scarring by the fourth week.

The cicatrization, most pronounced around the nerves, persisted throughout the series.

Basophilic calcium granules, present by the second week, were found in the scars in all the later specimens and in greatest quantity immediately around the nerves.

The agent showed a marked tendency to localize at the site of deposition.

Absolute alcohol, in one-week specimens (Fig. 11), produced an outright coagulation necrosis of the nerve, similar to that resulting with calcium hydroxide. A mild chronic inflammatory reaction, some fat necrosis and a very minimal amount of muscle necrosis also resulted (Fig. 12).

The two-week specimens exhibited less necrosis and more degenerative changes in the nerves than in the one-week specimens. The axis cylinders were destroyed, and demyelinization was complete. The architecture was preserved, although swollen. There was some muscle regeneration as well as an increase in fibrosis at the site of deposition of the agent.

The three- and four-week specimens exhibited the same degenerative changes in the nerve as was seen at two weeks. The chronic inflammatory response had disappeared, minimal muscle regeneration persisted, and the degree of fibrosis (most marked at the central site) was moderate.

Approximately 50 per cent of the nerve fascicles in the six-week specimens showed degenerative changes. The adjacent tissues were normal with the exception of some slight fibrosis in the central sections.

The eight-, ten-, and twelve-week specimens were normal in all respects.

The agent did not localize, as evidenced by changes in the proximal sections similar in nature but not in degree to those at the site of deposition.

DISCUSSION

It may be assumed, from the absence of tissue reaction or damage in the N/10 saline series, that the operative procedure per se produced none of the changes demonstrable with the other test agents.

The degree of reaction to an agent at the site of deposition appears to be related, in part, to its tendency to pool at the site or to diffuse along the longitudinal fascial planes.

Sylnasol produced nerve degeneration of comparatively short duration and appeared to have a relatively more selective action on the nerves in comparison with its effect on the adjacent tissues. The clinical experience of those clinicians using Sylnasol for nerve blocks and the findings of this study are in contradiction to the conclusions drawn by Schultz.[3, 4]

Benzyl alcohol in 5 and 10 per cent concentrations has produced nerve and tissue damage.[10, 11] The effects of 2 per cent benzyl alcohol were not determined in this study. However, it should be considered as producing at least some of the damage and reaction that resulted with injection of Sylnasol.

Sodium dicetyl phosphate produced no demonstrable nerve changes. Its local fibroplastic properties are good.[7] The intense giant-cell proliferation would appear to be in response to the olive oil.[10]

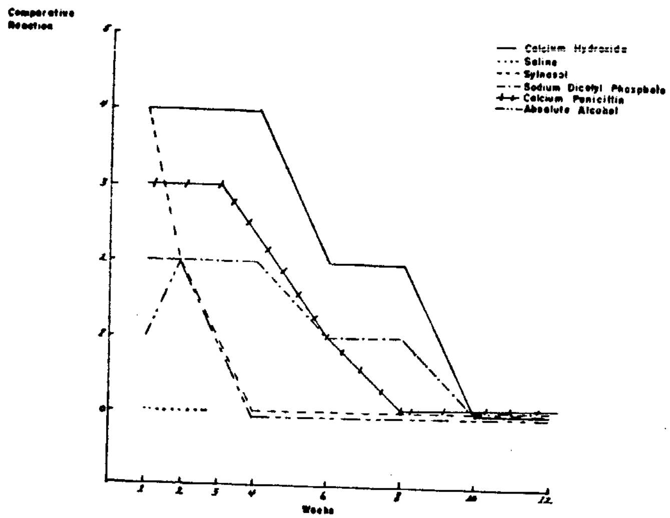


Chart 1.—Graphic representation of comparative reactions of tissues.

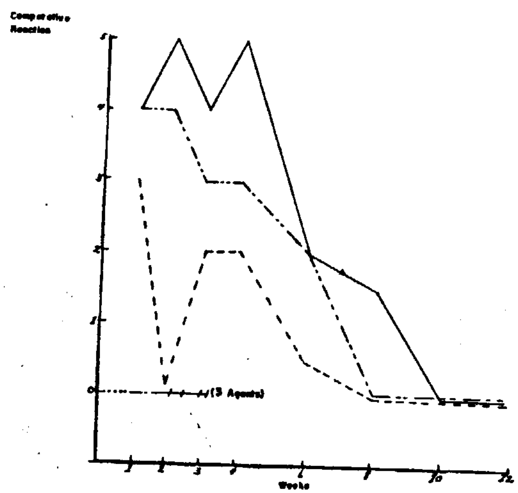


Chart 2.—Graphic representation of comparative reactions of nerves.

In all but one series, absolute alcohol produced degenerative rather than necrotic nerve changes, and an aseptic necrosis of fat and marginal musculature was seen in early specimens. The extent of degenerative changes produced by alcohol depends on the type of tissue injected. Skin and muscle tissues are not affected as severely as loose connective tissue or nerve tissue.[12]

"Strong alcohol" injected into a bundle of nerve fibers soon coagulates the albumin in the nerve sheath and fiber, resulting in degeneration of the nerve fibers.[13] In this study, absolute alcohol appeared to be the most highly specific agent for nerve tissue with the least amount of associated tissue reaction.

Absolute alcohol and Sylnasol had the same duration of damage to nerves.

Saturated calcium hydroxide solution produced nerve necrosis. The muscle and fat exhibited relatively greater destruction than the nerves. This is probably a result of the protection afforded the nerve by the perineurium. The distortion of the perineurium is indicative of nerve atrophy. The healing process with this agent was of interest in view of its tendency not to result in large amounts of cicatrization. The severity of the associated tissue reaction would probably contraindicate the use of this agent for clinical nerve blocks.

The results obtained with calcium penicillin are not in accord with those previously reported.[6] It is possible that the calcium granules and the dense scar around the nerves may produce functional changes in the nerves. On the basis of this study, calcium penicillin would not warrant clinical trial for nerve blocks.

CONCLUSION

This study indicates that the most effective agent, of those tested, for clinical nerve blocks is absolute alcohol.

Histopathologic changes in nerves are not necessarily a measure of the extent of functional changes which may occur. Nerves not damaged by an agent, as evaluated histopathologically, may undergo functional changes resulting in abnormalities of conduction.

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DIAGNOSIS AND TREATMENT PLANNING

ORAL DIAGNOSIS AND CONSULTATION

*H. A. Brayshaw, Lieutenant Colonel, DC, USA**

Technical advances in dental materials, equipment, and procedures accomplished by diligent persons and co-ordinated subsidized research projects are tremendous. These discoveries often precede general practical application by many years. Narrowing this gap between technical scientific knowledge and clinical application is a constantly evolving educational process. Dentists alert to learn and to apply the improved aids become the most astute diagnosticians and therapists. The processes of study and evaluation are the instrumentalities of genuine professioal advancement.

Oral diagnosis in dentistry is often given passive and cursory attention. It is really one of the most important daily considerations that confront us. An accurate diagnosis is a necessity in the intelligent formulation of a treatment plan. Immediate palliative treatment for expressed complaints is frequently the only treatment given. If we are to give dental service that is worthy of dentistry's position as a scientific health service, careful, thorough diagnosis and treatment planning must be inaugurated. The importance of diagnosis is now emphasized by the American Dental Association's Council on Dental Education. That group requires that all approved intern, graduate, and residency training include instruction by a qualified diagnostician. "The patient and the dentist benefit mutually from the time devoted to a comprehensive diagnosis."[1]

Special training in oral diagnosis is becoming available as an integral part of a well-balanced advanced training curriculum. To become an astute diagnostician, one must have a great deal of knowledge and repeated experience. An accumulation of experiences can be presented in a teaching situation, but these become more meaningful and more valuable as they become a personal challenge and are solved by the individual dentist. The ability to recall at the crucial time and, to use the knowledge gained is a mental discipline acquired by assiduous study and keen observation. Kolmer[2] stated: "Unfortunately it frequently is difficult and sometimes impossible for physicians

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(1949 to United States Vanadium Corp.); by heating a stoichiometric mixture of CaO or $CaCO_3$ and molybdic acid: Kroger, *Nature* 159, 674 (1947).

Tetragonal crystals. d 4.35. Insoluble in water, alcohol; sol in concd mineral acids.

USE: In phosphors and luminescent materials.

Calcium Nitrate. $Ca(NO_3)_2$; mol wt 164.10. Ca 24.42%, N 17.07%, O 58.50%. Prepn: *Gmelin's Handb. anorg. Chem.*, System no. 28 (Calcium), part B, 8th ed, pp 59–69, 341–382 (1956).

Deliquesc granules. mp about 560°. Very sol in water, heat being evolved; freely sol in methanol, ethanol, acetone; almost insol in concd HNO_3. pH of 5% aq soln 6.0. *Keep well closed.*

Note: Calcium nitrate crystallizes also with $4H_2O$ (30.5%), melting at 45°. Technical flake usually contains 28.6% H_2O.

USE: In explosives, fertilizers, matches, pyrotechnics; manuf of incandescent mantles, radio tubes, HNO_3; corrosion inhibitor in diesel fuels.

Calcium Nitrite. $Ca(NO_2)_2$; mol wt 132.10. Ca 30.34%, N 21.21%, O 48.45%. Prepd by reaction of nitric oxide with mixture of calcium ferrate(III) and calcium nitrate: Ray, Ogg, Jr., *J. Am. Chem. Soc.* 79, 265 (1957).

White or yellowish, deliquesc, hexagonal crystals. d 2.23. Freely sol in water; slightly sol in alc. *Keep well closed.*

USE: Corrosion inhibitor in lubricants.

Calcium Oleate. *Oleic acid calcium salt.* $Ca(C_{18}H_{33}O_2)_2$; mol wt 602.97. $C_{36}H_{66}CaO_4$; C 71.71%, H 11.03%, Ca 6.65%, O 10.61%. Prepn: Harrison, *Biochem. J.* 18, 1222 (1924); Pink, *J. Chem. Soc.* 1939, 619.

Pale-yellow transparent solid. Dec above 140°. Slowly absorbs moisture from the air to form the monohydrate. Practically insol in water, alcohol, ether, acetone, petr ether; sol in chloroform, benzene.

USE: Thickening lubricating grease; waterproofing concrete; emulsifier for benzene, kerosene, etc.; in modeling waxes to vary hardness.

Calcium Oxalate. CaC_2O_4; mol wt 128.10. C 18.75%, Ca 31.29%, O 49.96%. Prepn from calcium formate: Bredt, U.S. pat. 1,622,991 (1927); from calcium cyanamide: Barsky, Buchanan, *J. Am. Chem. Soc.* 53, 1270 (1931).

Hydrate, $CaC_2O_4.H_2O$, cubic crystals. Loses all of its water at 200°. When ignited is converted into $CaCO_3$ or CaO without appreciable charring. d 2.2. Practically insol in water or acetic acid; sol in dil HCl or HNO_3.

USE: In ceramic glazes; as carrier for separation of rare earth metals; analysis for calcium: Ingols, Murray, *Anal. Chem.* 21, 525 (1949).

Calcium Oxide. Lime; burnt lime; calx; quicklime. CaO; mol wt 56.08. Ca 71.47%, O 28.53%. Properly stored lime of commerce contains 90–95% free CaO. Commercial production from limestone: Faith *et al., Industrial Chemicals* (3rd ed, John Wiley & Sons, Inc., 1965), p 482. Laboratory prepn by ignition of $CaCO_3$: Ehrlich in *Handbook of Preparative Inorganic Chemistry*, G. Brauer, Ed., (2nd ed, Academic Press, 1963), p 931.

Crystals, white or grayish-white lumps, or granular powder; commercial material sometimes has a yellowish or brownish tint, due to iron. mp 2572°; bp 2850°; d 3.32–3.35. Readily absorbs CO_2 and H_2O from air, becoming air-slaked. Soluble in water, forming $Ca(OH)_2$ and generating a large quantity of heat; sol in acids, glycerol, sugar soln; practically insol in alc. *Keep tightly closed and dry.*

USE: In bricks, plaster, mortar, stucco and other building and construction materials; manuf of steel, aluminum, magnesium, and flotation of non-ferrous ores; manuf of glass, paper, Na_2CO_3 (Solvay process), Ca salts and many other industrial chemicals; dehairing hides; clarification of cane and beet sugar juices; in fungicides, insecticides, drilling fluids, lubricants; water and sewage treatment; in laboratory to absorb CO_2 (the combination with NaOH is known as soda-lime, *q.v.*). *Human Toxicity:* A strong caustic. May cause severe irritation of skin, mucous membranes.

Calcium Palmitate. *Palmitic acid calcium salt.* $Ca(C_{16}H_{31}O_2)_2$; mol wt 550.90. $C_{32}H_{62}CaO_4$; C 69.76%, H 11.34%, Ca 7.28%, O 11.62%. Prepn: Harrison, *Biochem. J.* 18, 1222 (1924).

Powder or rhombic crystals. Dec above 155°. Practically insol in water, alcohol, ether, acetone, petr ether; slightly sol in chloroform, benzene, acetic acid.

USE: Thickening lubricating oils; waterproofing fa... and lubricating greases; as corrosion inhibitor in h... hydrocarbons.

Calcium Pantothenate. *Pantothenic acid calcium* ...; calcium D(+)-N-(2,4-dihydroxy-3,3-dimethylbutyryl)-...ninate; Pantholin. $[HOCH_2C(CH_3)_2CHOHCONHCH_2CH_2COO]_2Ca$; mol wt 476.53. $C_{18}H_{32}CaN_2O_{10}$; C 45.3..., H 6.77%, Ca 8.41%, N 5.88%, O 33.57%. Prepn: W...meister, U.S. pat. 2,780,645 (1957 to Commercial Solv... Corp.); Kagan, U.S. pat. 2,845,456 (1958 to U... Purification: Kapp, Griffith, U.S. pat. 2,935,528 (196... Nopco Chemical Co.). Monograph: Greulich, M... *Pharmazie* 12, 643 (1957). *See also* Pantothenic Acid ... ref relating to prepn. Only the dextrorotatory isom... described here has vitamin activity.

Minute needles from methanol. Sweetish taste w... slightly bitter aftertaste. Dec 195–196°. Moderately hy...groscopic. Reasonably stable to air and light. $[\alpha]^{25}_D$ +2... (c = 5). Soluble in water; one gram dissolves in 2.8 ... H_2O; sol in glycerol; slightly sol in alcohol, acetone. pH of aq soln (1 in 20) is between 7.2 and 8.0; pH in CO_2-fr... water is 8.7. Calcium pantothenate solns are most sta... between pH 5 and 7. Rate of hydrolysis is a function of pH and is catalyzed by the presence of electrolytes. Solns ... not stable to autoclaving, and sterilization by filtration i... necessary. Stability data: Frost, McIntire, *J. Am. Chem. Soc.* 66, 425 (1944).

MED USE: *See* Pantothenic Acid.

VET USE: As source of pantothenic acid.

Calcium Permanganate. $Ca(MnO_4)_2$; mol wt 277.9... Ca 14.42%, Mn 39.53%, O 46.05%. Prepn from $KMnO_4$ and $CaCl_2$: Brit. pat. 624,885 (1949 to Boots Pure Drug Co. Ltd. and T. Hagyard); from $Al(MnO_4)_3$ and $Ca(OH)_2$: Jaskowiak, U.S. pat. 2,504,130 (1950 to Carus Chemical Co.).

Violet or dark-purple, deliquesc crystals. Freely sol in water; dec in alcohol. *Keep tightly closed.*

USE: Antiseptic, disinfectant, deodorizer; with CaF_2 as binder for welding electrode coatings and fluxes.

Calcium Peroxide. Calcium dioxide. CaO_2; mol wt 72.08. Ca 55.60%, O 44.40%. The commercial product usually contains about 60% CaO_2 = 13.3% available oxygen, with water and some $Ca(OH)_2$ and $CaCO_3$. Prepn: Young, U.S. pat. 2,533,660 (1950 to Du Pont); Ehrlich in *Handbook of Preparative Inorganic Chemistry*, G. Brauer, Ed., (2nd ed, Academic Press, 1963), p 936.

White or yellowish, odorless, almost tasteless powder. Dec in moist air. Slightly sol in water; sol in acids with formation of H_2O_2. *Keep well closed.*

USE: Stabilizer for rubber.

MED USE: Formerly as antiseptic oxidizing agent.

Calcium Phenolsulfonate. *p-Hydroxybenzenesulfonic acid calcium salt;* calcium sulfocarbolate; calcium sulfophenolate. $Ca[C_6H_4(OH)SO_3]_2$; mol wt 386.40. $C_{12}H_{10}CaO_8S_2$; C 37.30%, H 2.61%, Ca 10.37%, O 33.12%, S 16.60%. Prepn: *Hagers Handb. pharm. Praxis* vol. 2, 420 (Berlin, 1930).

Hydrate, $Ca[C_6H_4(OH)SO_3]_2.H_2O$, odorless cryst powder. Soluble in water or alcohol. The aq soln is neutral, and has a bitter, astringent taste.

VET USE: Has been used as an intestinal antiseptic, in dusting powders for ulcers and slowly granulating wounds and in ophthalmic solns.

Calcium Phenoxide. Calcium carbolate; calcium phenate; calcium phenolate; calcium phenylate. $Ca(OC_6H_5)_2$; mol wt 226.28. $C_{12}H_{10}CaO_2$; C 63.69%, H 4.45%, Ca 17.72%, O 14.14%. Prepn: Kluge, Drake, U.S. pat. 2,870,1... (1959 to Texas Co.).

Reddish powder. Dec in air. Slightly sol in water or alcohol. *Keep well closed.*

USE: Detergent; additive for motor oils.

Calcium Phosphate, Dibasic. Calcium monohydrogen phosphate; secondary calcium phosphate. $CaHPO_4$; mol wt 136.06. Ca 29.46%, H 0.74%, O 47.01%, P 22.77%. Prepn from $CaCl_2$ and Na_2HPO_4: Jensen, Rathley, *Inorg. Syn.* 4, 19, 20 (1953); from $Ca_3(PO_4)_2$ and H_3PO_4: Perloff, Posner, *ibid.* 6, 16 (1960), where it is an intermediate in the preparation of hydroxyapatite.

Anhydr, $CaHPO_4$, *monetite*. Triclinic crystals. At red

~~yst powder. Slight acetic acid-
-a water, practically insol in alc.
-- silage; as binder for fine-ore
-- lubricants.

-alciofon; Calglucon; Ebucin;
-HOCH$_2$(CHOH)$_4$COO]$_2$; mol
- 33.49%, H 5.16%, Ca 9.31%,
-pure.
-als, granules, or powder.
-ose its water on drying without
sol in 30 parts cold, about 5
alc or other organic solvents.
--7. More concd (20 to 30%)
-y the addition of boric acid or
-s. The use of calcium D-sac-
-satd injectable solns of calcium
-Calcium D-Saccharate. Inject-
-te contg sodium ascorbate are
and Ger. pat. 702,185. General
-Siegrist, *Pharm. Acta Helv.* 24,

-: in coffee powders to prevent

-ry. *Dose:* Oral 3 to 15 g/day;
May cause G.I., cardiac dis-

-ik fever of cattle, pregnancy
- convulsions, lactation eclamp-
-... I.v. in Mg, Hg, Pb, CCl_4
-ns where the prompt action of
-rses and cattle 25-100 g i.v.,
swine 4-5 g i.m. or i.v.; dogs

-e. Glycerophosphoric acid
glycerol esters calcium salt;
-O$_3$C: acid salt; HOCH$_2$-
salt wt 210.15. C_3H_7-
-c, C -.07%, O 45.69%,
-: the *β-glycerophosphoric acid*
and L(−)-forms of *α-glycero-*
-ommercial product is mixture
-rophosphates: Toal, Phillips,
--19). Prepn of the calcium salt
-man, *J. Chem. Soc.* 105, 1238
Separation of the α-acid from
acids via the α-acid calcium
(1950), *C.A.* 46, 5077a (1952).
-- odorless, almost tasteless,
-ec >170°. Soluble in about
-oiling water; soly in water is
-ad; almost insol in alc. The

powder, as food stabilizer.
-sphorus dietary supplement.

source of calcium and phos-
these elements. Formerly in

Calcium fluosilicate; calcium
-82.17. Ca 22.00%, F 62.58%,
- and H_2SiF_6: Moller, Kreth,

-owder. d 2.25. Almost insol
-ot water; practically insol in
- pigs: 250 mg/kg.
- industries; flotation agent;

-mol wt 42.10. Ca 95.21%,
-ombination of calcium and
-597,055 (1948); by reduction
-resence of hydrogen: Gibb,
-78-211 (1948); from $CaCl_2$
sodium: Wade, Alexander,
-al Hydrides, Inc.). *Reviews:*
-); Kilb, *USAEC* APEX-455,

-mmer -l product is gray.
-n w lower alcohols and
-gen -lerately powerful
-d ac-, esters; more power-
-al oxides than lithium or

USE: To prepare rare metals by reduction of their oxides; as a drying agent for liquids and gases; to generate hydrogen: 1 g of calcium hydride in water liberates 1 liter of hydrogen at STP; in organic syntheses.

Calcium Hydroxide. Calcium hydrate; slaked lime. $Ca(OH)_2$; mol wt 74.10. Ca 54.09%, H 2.72%, O 43.10%. Contains at least 95% $Ca(OH)_2$. Commercial prepn by hydration of lime: Faith *et al., Industrial Chemicals,* (3rd ed, John Wiley & Sons, Inc., 1965), p 483. Laboratory prepn by treating an aq soln of a calcium salt with alkali: Ehrlich in *Handbook of Preparative Inorganic Chemistry,* G. Brauer, Ed., (2nd ed, Academic Press, 1963), p 934.

Crystals or soft, odorless, granules or powder. Slightly bitter, alkaline taste. Readily absorbs CO_2 from air forming $CaCO_3$. When ignited it loses H_2O leaving CaO. d 2.08-2.34. Slightly sol in water; sol in glycerol, sugar or NH_4Cl solns; sol in acids with evolution of much heat. pH of aq soln satd at 25°: 12.4. *Keep well closed.* LD_{50} orally in rats: 7.34 g/kg.

USE: In mortar, plaster, cement and other building and paving materials; in lubricants, drilling fluids, pesticides, fireproofing coatings, water paints; as egg preservative; manuf of paper pulp; in SBR rubber vulcanization; in water treatment; dehairing hides.

MED USE: Topical astringent in soln or lotion. (Calcium Hydroxide Solution, U.S.P.)

Calcium Hypochlorite. Losantin. Improperly called calcium oxychloride. $Ca(OCl)_2$; mol wt 142.99. Ca 28.03%, Cl 49.59%, O 22.38%. Pure product has not been prepd. Commercial products usually contain 50% or more $Ca(OCl)_2$. Prepn of solid product contg 90-94% $Ca(OCl)_2$: Cady, *Inorg. Syn.* **5**, 161 (1957). Impurities include $Ca(ClO_4)_2$, $CaCl_2$, $CaCO_3$, $Ca(OH)_2$ and water.

USE: Algaecide, bactericide, deodorant, disinfectant, fungicide; in sugar refining; oxidizing agent; bleaching agent. Ingredient of ***Caporit*** which also contains NaCl. Also ingredient of ***HTH*** and ***Perchloron.***

Calcium Hypophosphite. $Ca(H_2PO_2)_2$; mol wt 170.07. Ca 23.57%, H 2.37%, O 37.63%, P 36.43%. Prepn: *Gmelin's Handb. anorg. Chem.,* System no. 28 (Calcium), part B, 8th ed, pp 1119-1121 (1958).

Monoclinic, prismatic crystals or granular powder. When heated above 300° it evolves spontaneously-inflammable phosphine. Soluble in water; slightly sol in glycerol; practically insol in alcohol. The aq soln is slightly acid. *Incompat.* KI, oxidizers.

USE: As corrosion inhibitor; in nickel plating.

MED USE: Formerly in various conditions of impaired nutrition.

VET USE: Formerly used as a nerve tonic, prescribed in syrups with other ingredients. Of doubtful value.

Calcium Iodate. Lautarite. $Ca(IO_3)_2$; mol wt 389.90. Ca 10.28%, I 65.10%, O 24.62%. Prepd by passing chlorine into a hot soln of lime in which iodine has been dissolved: Bahl, Singh, *J. Indian Chem. Soc.* **17**, 397 (1940).

Nonhygroscopic, monoclinic-prismatic crystals. d_4^{15} 4.519. Stable up to 540°. Sensitive to reducing agents. Solubility in water at 0° = 0.10 g/100 ml; at 100° = 0.95 g/100 ml. More sol in aq solns of iodides and in amino acid solns. Soluble in nitric acid. Insoluble in alcohol.

Monohydrate, $Ca(IO_3)_2.H_2O$, cubic crystals. Slightly sol in water.

Hexahydrate, $Ca(IO_3)_2.6H_2O$, orthorhombic crystals. Slightly sol in water.

USE: Nutritional source of iodine in foods and feedstuffs. More stable in table salt than iodides: *Food Field Reporter,* Aug. 8, 1956; Daum, *C.A.* **51**, 5324 (1957); to improve properties of yeast-leavened bakery products.

MED USE: Anhydr salt formerly as topical disinfectant. Hexahydrate formerly as antiseptic, deodorant.

Calcium Iodide. CaI_2; mol wt 293.90. Ca 13.64%, I 86.36%. Prepn: *Gmelin's Handb. anorg. Chem.,* System no. 28 (Calcium), part B, 8th ed, pp 102, 610-622 (1958); Chaigneau, *Bull. Soc. Chim. France* 1957, 886; Farr, U.S. pat. 2,415,346 (1947 to Mallinckrodt Chemical Works). The commercial product usually contains 16-20% water.

Very hygroscopic hexagonal lamella. Becomes yellow and completely insol on exposure to air due to liberation of I_2 and absorption of CO_2. mp 740°; bp 1100°. Very sol in water, methanol, ethanol, acetone; practically insol in ether, dioxane. The aq soln is neutral or slightly alkaline. *Keep tightly closed and protected from light.*

Hexahydrate, $CaI_2.6H_2O$, hexagonal, thick needles or plates or lumps or powder. Very hygroscopic; becomes yellow in air. mp about 42°. Freely sol in water, alcohol. *Keep tightly closed and protected from light.*

MED USE: Expectorant.

Calcium Iodobehenate. *Iododocosanoic acid calcium salt;* Caliobén; Saiodin; Sajodin. $Ca(C_{21}H_{42}ICO_2)_2$; mol wt 971.03. $C_{44}H_{84}CaI_2O_4$; C 54.42%, H 8.72%, Ca 4.13%, I 26.14%, O 6.59%. Prepn: *Beilstein* vol. 2, 392.

White or yellowish powder; odorless or with slight fat-like odor. Practically insol in water, alcohol, ether; freely sol in chloroform. *Protect from light.*

MED USE: Intern. for its iodine action. *Dose:* Oral 0.5 g. *Side Effects:* G.I. disturbances, iodism may occur.

VET USE: *See* Sodium Iodide.

Calcium Iodostearate. *2-Iodooctadecanoic acid calcium salt;* stearodine. $Ca(C_{17}H_{34}ICO_2)_2$; mol wt 858.82. $C_{36}H_{68}CaI_2O_4$; C 50.34%, H 7.98%, Ca 4.67%, I 29.56%, O 7.45%. Prepn: *Beilstein,* vol. 2, 1st suppl., 177.

Cream-colored, almost odorless powder. Practically insol in water or alcohol; sol in benzene, chloroform, ether.

MED USE: Formerly for prophylaxis and treatment of simple colloid goiter.

VET USE: *See* Sodium Iodide.

Calcium Lactate. $Ca[CH_3CH(OH)COO]_2$; mol wt 218.22. $C_6H_{10}CaO_6$; C 33.02%, H 4.62%, Ca 18.37%, O 43.99%. The article of commerce usually contains about 25% water, and on the anhydr basis it is at least 98% pure. Prepd commercially by neutralization of lactic acid, from fermentation of dextrose, molasses, starch, sugar or whey, with $CaCO_3$: Inskeep *et al., Ind. Eng. Chem.* **44**, 1955 (1952).

Pentahydrate, $Ca(C_3H_5O_3)_2.5H_2O$, almost odorless, slightly efflorescent granules or powder. Becomes anhydr at 120°. pH: 6-7. Slowly sol in cold water, quickly sol in hot water; almost insol in alcohol.

USE: In the food and beverage industries; in dentrifrices.

MED USE: *See* Calcium Gluconate.

VET USE: As for calcium gluconate. *Dose:* horses and cattle: 50-100 g; sheep and swine: 4-5 g (larger doses for adult swine); dogs: 1-2 g.

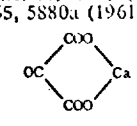
Calcium Levulinate. ***Levulinic acid calcium salt.*** $(CH_3COCH_2CH_2COO)_2Ca$; mol wt 270.30. $C_{10}H_{14}CaO_6$; C 44.43%, H 5.52%, Ca 14.83%, O 35.52%. Prepn: Cox, Dodds, U.S. pat. 2,033,909 (1936 to Niacet Chemicals Corp.).

Dihydrate, $(C_5H_7O_3)_2Ca.2H_2O$, crystals or granular powder. mp 125°. Loses $1H_2O$ on drying *in vacuo* at room temp and all H_2O at 50°. Very sol in water; the aq soln is practically neutral.

MED USE: Calcium deficiency. *Dose:* Oral 4 to 5 g; s.c., i.m. or i.v. 1 g. *Side Effects: See* Calcium Gluconate.

VET USE: *See* Calcium Gluconate.

Calcium Mesoxalate. *Mesoxalic acid calcium salt;* calcium ketomalonate; calcium oxomalonate; ketomalonic acid calcium salt; oxomalonic acid calcium salt; Mesoxan. C_3CaO_5; mol wt 156.11. C 23.08%, Ca 25.67%, O 51.25%. Prepn: Scheiber, Hopfer, *Ber.* **53**, 908 (1920); Kobayashi, Jap. pat. 4157('52); *C.A.* **48**, 5212a (1954), Yanagisawa, Jap. pat. 7463('60); *C.A.* **55**, 5880a (1961).



Crystalline powder, dec 210-220°. Sparingly sol in glacial acetic acid. *Note:* May also exist as calcium dihydroxymalonate.

Calcium Methionate. *Methanedisulfonic acid calcium salt.* $CaCH_2(SO_3)_2$; mol wt 214.24. $CH_2CaO_6S_2$; C 5.61%, H 0.94%, Ca 18.71%, O 44.81%, S 29.93%. Prepn: *Beilstein* vol. 1, 1st suppl., 303; Jenkins, *J. Am. Pharm. Assoc.* **27**, 484 (1938).

Dihydrate, $CaCH_2(SO_3)_2.2H_2O$, crystals or cryst powder, having a slight odor. Stable in air. Soluble in about 2.5 parts water forming a neutral soln (pH 6-7); very slightly sol in alc.

Calcium Molybdate(VI). $CaMoO_4$; mol wt 200.03. Ca 20.04%, Mo 47.98%, O 32.00%. Prepn from sodium molybdate and $CaSO_4$: Carosella, U.S. pat. 2,460,974

The Lethal Effect of Certain Chemicals on Fresh Water Fish

by N. H. SANBORN
National Canners Assn. Research Laboratories

THE disposal of cannery wastes frequently involves the use of chemicals for treatment purposes. Ferrous sulfate, alum and lime are used in chemical coagulation; sodium carbonate for acidity control in biological filters; and sodium nitrate in lagoons for odor control. Lye (sodium hydroxide) peeling of certain fruits and vegetables is not uncommon. These chemicals, in whole or in part, are discharged in most cases to a stream. In view of several claims of death of fish allegedly due to discharge of lye, it was felt desirable to investigate the lethality to fish of the chemicals commonly used.

The discharge of cannery waste may be effected (1) as a continuous discharge over a period of hours as in the case of biological treatment and continuous flow chemical coagulation or (2) intermittently following batch chemical treatment and periodic dumping of lye-peeling solutions. The method of discharge may be a factor governing the deadlines of a chemical pollutant. Experimental conditions were such that both methods of discharge were investigated.

Experimental

CONTINUOUS DISCHARGE TESTS. Three species of fish were used: 2-3 inch common goldfish, 3-4 inch largemouth bass* (*micropterus salmoides*) and 1.5-2.5 inch bluegill sunfish* (*lepomis machrochirus*). Aquaria water and water used for chemical solutions was Washington, D. C., tap water having, during the period of testing, 64 to 80 parts per million (ppm) total hardness, of which 28 to 36 ppm was non-carbonate hardness. The water had a pH of 7.2 to 7.6 and would be classed as a bicarbonate water of medium hardness. For any one test 2 fish of the same species were placed in an aquarium holding 6 liters of solution. Fresh solution was added continuously at the bottom of t e aquarium from a constant delivery reservoir at the rate of 1 to 1.5 liters per hour, the overflow discharging at the surface. This rate proved sufficient to maintain a constant solution composition as judged by a constant pH. The disturbing effects of carbon dioxide from respiration, bacterial decomposition, and surface absorption were thereby eliminated. Reservoir air intakes were provided with soda lime tubes to prevent carbon dioxide absorption. Aquaria containing ferrous sulfate solutions were aerated with carbon dioxide free air for short periods of time twice daily. Unconsumed food and debris were removed by suction. Aquaria were covered with screens to prevent fish from jumping out.

Every concentration of each chemical solution was tested with 2 fish of the 3 different species. Goldfish were fed with a commercial fish food. The large-mouth bass and bluegill sunfish received earthworms. Each test extended over a period of 7 days, following which the surviving fish were removed to fresh water for further observation over a period of several days.

In preparing the solutions, chemically pure salts were used without water of crystallization, except in the case of ferrous sulfate and aluminum sulfate (alum) which contained 7 and 18 molecules water of crystallization, respectively.

*Obtained through the courtesy of the Fish and Wildlife Service, U. S. Department of the Interior.

TABLE I
Survivals of Fish in Various Chemicals Whose Concentrations Were Maintained Constant

Substance	Concentration in p.p.m.	Type of fish	pH of solution	Survival time[1]
Sodium hydroxide	50	Goldfish	10.4	∞
do	100	do	10.9	3 to 20 hours
do	50	Largemouth bass	10.4	∞
do	50	Bluegill sunfish	10.4	∞
Calcium hydroxide	50	Goldfish	10.5	∞
do	100	do	11.1	3 to 3.5 hours
do	50	Largemouth bass	10.5	∞
do	100	do	11.1	3 to 5 hours
do	50	Bluegill sunfish	10.5	∞
do	100	do	11.1	2 to 4.5 hours
Sodium carbonate	200	Goldfish	10.1	∞
do	500	do	10.6	∞
do	100	Largemouth bass	9.7	∞
do	200	do	10.1	4.3 to 4.5 days
do	500	do	10.6	7 to 9 hours
do	200	Bluegill sunfish	10.1	∞
do	500	do	10.6	4.5 to 11 hours
Ferrous sulfate	100	Goldfish	6.4	∞
do	50	Largemouth bass	[illegible]	∞
do	100	do	[illegible]	4.2 to 7 days
do	50	Bluegill sunfish	6.6	∞
do	100	do	6.4	2.5 to 3.5 days
Aluminum sulfate	100	Goldfish	5.6	∞
do	100	Largemouth bass	5.6	∞
do	100	Bluegill sunfish	5.6	∞
Sodium nitrate	1000	Goldfish	7.3	∞
do	2000	do	7.4	4 days
do	4000	do	7.4	14 to 26 hours
do	2000	Largemouth bass	7.4	∞
do	4000	do	7.4	∞
do	1000	Bluegill sunfish	7.3	∞
do	2000	do	7.4	3 days to ∞
do	4000	do	7.4	14 hours to ∞

[1] Infinity sign indicates survival greater than 7 days.

Single Discharge Tests. The general experimental conditions were similar to the above, except that only 2 liters of test solution per aquarium were used and no further additions were made to maintain the original concentration. Goldfish and large-mouth bass were the only test fish used. Shallow aquaria were used to permit adequate surface aeration. Since it was desired to retain the original solution, no attempt was made to clean the aquaria other than picking out unconsumed food which remained in the more concentrated solutions.

Discussion

The survival times of the test fish under the two different experimental conditions are given in Tables I and II. Following the procedure of Ellis (1), the infinity sign indicates survival to the end of the test period, in this case 7 days. However, no claim is implied that the fish would continue to live and breed if such conditions were maintained indefinitely. Changes in pH in particular would be expected to affect adversely the aquatic environment and its proper balance so necessary for maintaining a supply of fish food.

Chemical coagulants used in treating cannery waste are calcium hydroxide, together with either ferrous sulfate or alum. An excess of calcium hydroxide is always employed. Consequently the quantity of ferrous, ferric (from oxidation of ferrous) and aluminum ions present in the treatment of plant effluent is limited by the solubility of ferrous, ferric and aluminum hydroxide, together with such quantities of these materials as may be mechanically carried over by incomplete sedimentation.

Actually, the concentration of these substances discharged in treated wastes is of no consequence. For example, a sample from a cannery-operated treatment plant was obtained without the knowledge of the plant operator. Treatment consisted of the coagulation of 25,000 gallons of pea waste with 150 pounds of lime and 75 pounds of ferrous sulfate followed by sedimentation. The effluent was found to contain a total of 1.4 ppm of iron equivalent to 7 ppm of ferrous sulfate ($Fe\ SO_4 \cdot 7H_2O$). Reference to the tabulated data show that such a low concentration, even if it were discharged in the form of ferrous sulfate, which of course it is not, would not be injurious to fish. Ferrous sulfate in concentrations used in these experimental tests was precipitated as ferric hydroxide. Death of fish in solution containing a concentration of ferrous sulfate of 100 ppm or greater appeared to be due to accumulation of ferric hydroxide on the gills. Alum undergoes a similar hydrolysis.

Mention was made of the fact that an excess of lime is used in chemical coagulation. The amount in solution which is discharged in the effluent is influenced by the buffering capacity of the waste and the degree of alkalinity required for optimum coagulation. The latter generally lies between pH 10 and 11. For example, pea waste which has a high buffering capacity when discharged after treatment and having a pH of 10.6 contained 144 ppm calcium hydroxide. If such a waste were discharged into a receiving body of water at the very low dilution ratio of 1 part waste to 2 parts of receiving water, the resultant concentration of calcium hydroxide would be reduced by dilution alone to a value below the 50 ppm concentration shown in the tables to be without effect on fish.

Sodium nitrate is used to prevent development of objectionable odors in lagooned cannery waste. These wastes are not discharged into a receiving body of water until such time as the wastes have been reduced to a very low and innocuous biochemical oxygen demand. Long before this state has been achieved, the added sodium nitrate has been completely converted into sodium carbonate or bicarbonate. Considering the worst possible condition which might occur, such as a break in the lagoon wall, the maximum concentration of sodium carbonate would not exceed 600 ppm. A 1 to 2 dilution would render this waste harmless.

Under actual operating conditions the concentration of sodium carbonate is of such a low order of magnitude that bacterial activity is not inhibited, and after several weeks numerous forms of higher plant and animal life abound in the lagoon. Sodium carbonate is sometimes used to control the acidity of cannery waste

TABLE II
Survivals of Gold Fish and Large Mouth Bass in Various Concentrations of Several Chemicals

Substance	Concentration in p.p.m.	pH of solution at stated intervals: Initial	1 day	3 days	7 days	Survival time[1]
Sodium hydroxide ..	5	8.9	7.4	7.4	7.4	∞
do	10	9.3	7.7	7.5	7.5	∞
do	25	9.9	7.8	7.7	7.7	∞
do	50	10.4	8.6	7.9	7.9	∞
do	100	10.9	9.5	...	...	3 to 10 hours[2]
Calcium hydroxide ..	10	9.4	7.4	7.4	7.7	∞
do	25	10.2	7.7	7.7	7.7	∞
do	50	10.7	7.8	7.7	7.7	∞
do	100	11.1	7.8	7.5	7.7	Goldfish ∞, Bass, 7 hrs. to 3 days
do	200	11.4	...	...	...	30 to 80 minutes
do	500	11.8	...	...	...	20 to 53 minutes
Sodium carbonate ...	10	8.5	7.4	7.5	7.5	∞
do	25	8.9	7.4	7.5	7.5	∞
do	50	9.6	7.6	7.5	7.5	∞
do	100	9.9	8.1	7.6	7.6	∞
do	200	10.1	9.0	8.0	8.0	∞
do	500	10.5	9.8	8.3	8.3	Goldfish ∞, Bass, 10 and 23 hrs.
Ferrous sulfate	50	6.6	6.7	...	7.2	∞
do	100	6.3	6.1	...	7.2	∞
do	500	5.6	5.5	...	...	Goldfish, 1.3 to 5 days Bass, 9 to 23 hours
do	1000	5.2	5.2	...	...	Goldfish, 5 to 30 hrs. Bass, 2.5 to 9 hours
Aluminum sulfate ...	25	7.0	7.3	7.2	7.5	∞
do	50	6.6	6.9	7.2	7.4	∞
do	100	5.6	6.1	6.5	7.1	∞
do	250	4.5	4.5	...	...	Goldfish, between 15 and 24 hours Bass, between 8 and 23 hours
do	500	4.4	4.4	...	...	Between 8 and 23 hrs.

[1] Infinity sign indicates survival greater than 7 days.
[2] One goldfish survived the 7-day test, but died several days later during the period of observation in fresh water.

applied to trickling filters. The quantity of sodium carbonate discharged in the filter effluent varies with the control required, but always is a very small quantity compared with the concentration required to kill fish. If waste treated with the maximum amount of sodium nitrate were inadvertently discharged to a receiving body of water instead of the lagoon, the concentration of sodium nitrate, without considering dilution, would be below 1,000 ppm and without adverse effect on fish.

Sodium hydroxide is utilized in the lye-peeling of certain fruits and vegetables. The concentrations of sodium hydroxide used vary over a wide range, depending on a number of factors, but are seldom less than 3 per cent. The periodic discharge of lye-bath waste requires careful consideration of the sodium hydroxide concentration in the receiving body of water. As indicated in Table I, continuous exposure for 7 days to a concentration of 50 parts per million was not fatal. Fortunately, lye baths are seldom discharged more frequently than once a day. If a lye bath is discharged directly into a receiving body of water, the rate of discharge should be controlled to insure a sodium hydroxide concentration of not more than 50 ppm.

The experimental conditions set up in these tests are more rigorous than actually occur in practice. The continuous maintenance of any given concentration of chemicals in a receiving stream is not possible because chemical containing wastes are not discharged continuously. However, a body of contaminated water would tend to proceed downstream as a unit, maintaining the chemical concentration until such time as natural agencies modify it. Fortunately, such modification is obtainable from several sources, other than additional dilution. Carbon dioxide derived from atmospheric absorption, respiration of aquatic animal life and decomposition of organic matter reduce excess alkalinity. Under the simple and quiescent conditions prevailing in the tests reported in Table II, it will be noted that the original alkalinity of the 50 ppm calcium hydroxide solution was reduced from pH 10.7 to 7.8 in one day, a value frequently encountered in natural waters. Similar results were obtained with the other alkaline solutions. On the other hand, solutions which were originally acid, ferrous sulfate and alum, slowly attained the approximate pH normal to the water in which they were dissolved.

It is well known that the toxicity of metallic salts is influenced by the hardness of the water. Many natural watercourses have a degree of hardness in excess of that used in these tests. Such waters would tolerate a higher concentration of toxic metals. Hardness likewise plays an important role in resisting changes to the original pH of the stream by reaction with either alkaline or acid salts.

Considering the kind and quantity of chemicals used by the canning industry, the methods of disposal and reaction in a receiving body of water it hardly seems possible that such chemicals can be toxic t fish.

Summary

1. The lethality of chemicals used by the canning industry in waste treatment or lye peeling operations on fresh-water fish has been investigated.

2. Concentrations of 100 ppm sodium hydroxide, calcium hydroxide and ferrous sulfate, 200 ppm sodium carbonate, 250 ppm aluminum sulfate and 2,000 ppm sodium nitrate in water of medium hardness were lethal to fish within 7 days.

3. Concentrations of 50 ppm sodium hydroxide, calcium hydroxide and ferrous sulfate, 100 ppm sodium carbonate and aluminum sulfate and 1,000 ppm sodium nitrate in water of medium hardness were not fatal or apparently injurious to fish during a 7-day exposure.

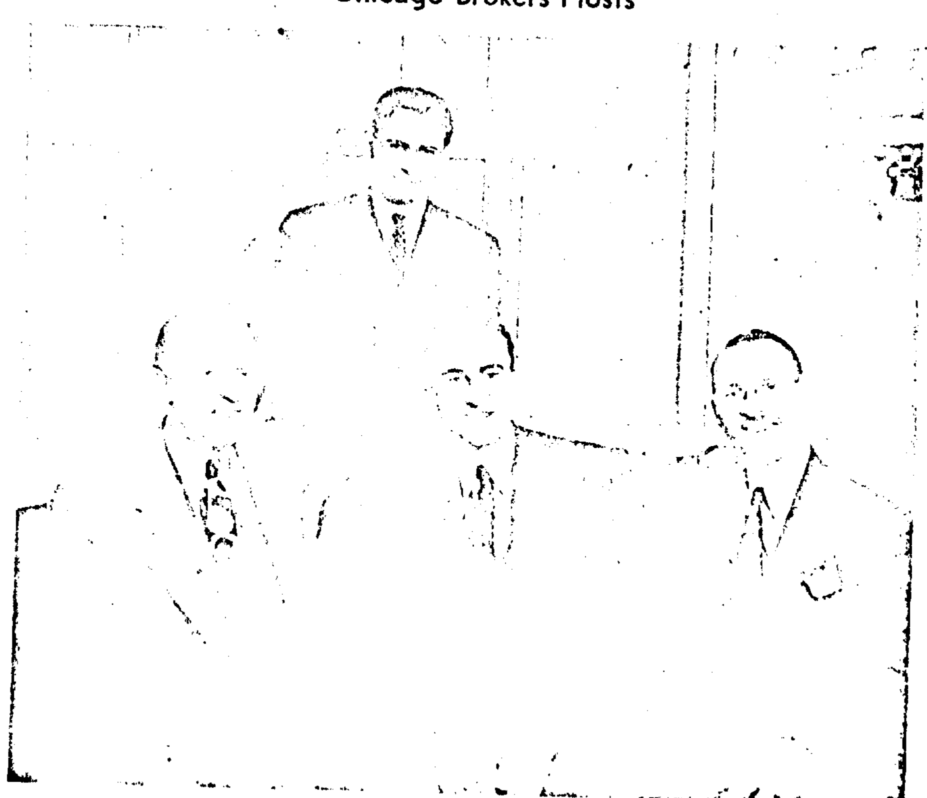
4. Discharge of the above chemicals under prevailing conditions and with moderate dilution are not toxic to fish.

Reference

(1) Ellis, M. M., Detection and Measurement of Stream Pollution, U. S. Bureau of Fisheries, Bulletin No. 22, 1937.

California olive growers have a smaller crop this year than last. Bidding of canners and processors will assure them a good price.

Chicago Brokers Hosts



When Jack P. Sexton moved east to one of the John Sexton Co. branches, Chicago brokers who have been doing business with him tendered him a testimonial luncheon. Shown here (seated) are Gladdon W. Pickett, Sanborn Holmes & Co., Mr. Sexton and William W. Wurm, Wurm Bros. Co. Standing is Joe Putz who succeeds Mr. Sexton as assistant to H. R. White, canned foods buyer.

Table II
Acute Oral Toxicity of Some Inorganic Compounds for Rats

Material*		Formula	Single Oral LD_{50} for Rats gm/Kg	Concentration Intubated gm/ml**	
Aluminum isopropylate	T	$Al[OCH(CH_3)CH_3]_3$	11.3 (7.0 -18.3)	0.200	A
Aluminum nitrate		$Al(NO_3)_3 \cdot 9H_2O$	4.28 (3.86 - 4.76)	0.100	
Ammonium metavanadate	T	NH_4VO_3	0.16 (0.12 - 0.21)	0.0025	B
Ammonium paratungstate	T	$(NH_4O)_6W_7O_{18} \cdot 6H_2O$	11.3	0.400	A
Ammonium persulfate		$(NH_4)_2S_2O_8$	0.82 (0.53 - 1.26)	0.200	
Borax		$Na_2B_4O_7 \cdot 10H_2O$	5.66	0.010	
Boric acid		H_3BO_3	5.14 (4.75 - 5.58)	0.200	
Calcium acetate		$Ca(OOCCH_3)_2 \cdot H_2O$	4.28 (3.86 - 4.76)	0.100	
Calcium acrylate	T	$Ca(OOCCH{=}CH_2)_2 \cdot H_2O$	4.92 (3.75 - 6.46)	0.200	A
Calcium cyanide		$Ca(CN)_2$	0.039(0.030- 0.051)	0.001	
Calcium hydroxide		$Ca(OH)_2$	7.34 (4.83 -11.14)	0.100	
Calcium propionate	T	$Ca(OOCCH_2CH_3)_2 \cdot H_2O$	5.16 (4.17 - 6.38)	0.100	
Chromium acetate	T	$Cr(OOCCH_3)_2 \cdot H_2O$	11.26	0.200	
Chromium chloride (ous)	T	$CrCl_2$	1.87 (1.21 - 2.87)	0.050	
Chromium nitrate (ic)		$Cr(NO_3)_3 \cdot 9H_2O$	3.25 (2.11 - 4.99)	0.200	
Cobalt oxide	T	CoO	1.70 (1.07 - 2.82)	0.100	A
Copper acetate		$Cu(OOCCH_3)_2 \cdot H_2O$	0.71 (0.60 - 0.83)	0.010	
Copper nitrate		$Cu(NO_3)_2 \cdot 3H_2O$	0.94 (0.61 - 1.43)	0.200	
Copper sulfate		$CuSO_4 \cdot 5H_2O$	0.96 (0.71 - 1.30)	0.050	
Cuprous oxide	T	Cu_2O	0.47 (0.34 - 0.66)	0.100	A
Diammonium decaborane	T	$(NH_3)_2B_{10}H_{14}$	3.56 (1.85 - 6.86)	0.050	
Dicumene chromium	T	$(C_9H_{12})_2Cr$	0.81 (0.62 - 1.07)	0.100	M
Ferric nitrate		$Fe(NO_3)_3 \cdot 9H_2O$	3.25 (2.56 - 4.26)	0.200	
Ferrous ammonium sulfate		$(NH_4)_2SO_4 \cdot FeSO_4 \cdot 6H_2O$	3.25 (2.48 - 4.26)	0.300	
Lithium carbonate		Li_2CO_3	0.71	0.200	
Magnesium chloride		$MgCl_2 \cdot 6H_2O$	8.1 (7.3 - 9.1)	0.100	
Manganous acetate		$Mn(OOCCH_3)_2 \cdot 4H_2O$	3.73 (2.68 - 5.21)	0.200	
Nickel nitrate		$Ni(NO_3)_2 \cdot 6H_2O$	1.62 (1.06 - 2.50)	0.200	
Potassium acetate		$KOOCCH_3$	3.25 (2.48 - 4.26)	0.100	
Potassium carbonate		K_2CO_3	1.87 (1.34 - 2.60)	0.200	
Potassium hydroxide		KOH	1.23 (0.80 - 1.89)	0.100	
Potassium permanganate		$KMnO_4$	1.09 (0.70 - 1.71)	0.020	
Silver oxide	T	Ag_2O	2.82	0.200	A
Sodium arsenite		$NaAsO_2$	0.041(0.031- 0.053)	0.010	
Sodium cyanide		$NaCN$	0.015(0.011- 0.021)	0.0004	
Sodium fluoride		NaF	0.18 (0.12 - 0.26)	0.005	
Sodium nitrite		$NaNO_2$	0.18	0.010	
Sodium phosphate, diabasic		$Na_2HPO_4 \cdot 7H_2O$	12.93 (9.85 -16.97)	0.200	
Sodium phosphate, tribasic		$Na_3PO_4 \cdot 12H_2O$	7.40 (6.81 - 8.03)	0.200	
Sodium tripolyphosphate	T	$Na_5P_3O_{10}$	6.50 (4.03 -10.48)	0.200	
Sulfuric acid		H_2SO_4	2.14 (1.54 - 2.99)	0.250	
Vanadium dichloride	T	VCl_2	0.54 (0.38 - 0.75)	0.010	A
Vanadium oxytrichloride	T	$VOCl_3$	0.14 (0.09 - 0.22)	0.050	M
Vanadium tetrachloride	T	VCl_4	0.16	0.090	M
Vanadium trichloride	T	VCl_3	0.35 (0.22 - 0.57)	0.100	
Zinc acetate		$Zn(OOCCH_3)_2 \cdot 2H_2O$	2.46 (1.60 - 3.78)	0.200	
Zinc naphthenate	T		4.92 (3.75 - 6.46)	0.200	L

* T Preceding formula designates technical grade, or development sample, otherwise reagent grade
** Intubation concentrations are in water except as noted by following symbols:
M In mineral oil
L In lard
A Suspended in 0.25% agar
B Suspended in 5% bentonite

Use of Expired Air-Carbon Monoxide for Carboxyhemoglobin Determinations in Evaluating Carbon Monoxide Exposures Resulting from the Operation of Gasoline Fork Lift Trucks in Holds of Ships

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Exposures of longshoremen to carbon monoxide from fork lift trucks used in holds of ships were evaluated by use of the expired air method for determining carboxyhemoglobin. Results indicated that if the net increase in carboxyhemoglobin was considered, then the hazards potential of utilizing gasoline driven fork lifts in the holds would be considered of low order of magnitude. Moderate to heavy cigarette smoking was probably as important a factor in individual carbon monoxide adsorption as being exposed to CO at the Threshold Limit Value (TLV).

Introduction

FREQUENTLY IT IS necessary, when loading and unloading cargo, to utilize fork lift trucks (Figure 1) in holds of ships. If these vehicles are gasoline driven, workmen, including stevedores and lift drivers (bull operators), are exposed to gasoline exhaust products of which carbon monoxide is the major potentially dangerous component, particularly when emitted in confined spaces.

Effects of Carbon Monoxide

Carbon Monoxide is considered to be a chemical asphyxiant since it combines with blood in preference to oxygen to form carboxyhemoglobin (COHb), thereby reducing the oxygen carrying capacity of the blood. There are usually no symptoms with blood COHb levels under 5%. At approximately 10%, COHb symptoms such as headache, fatigue and dizziness may be experienced.

Disturbances of coordination, judgment, psychomotor tasks and visual acuity appear at about 2% blood COHb but do not become significant until approximately 5% COHb saturation is reached.

Schulte,[2] in a study of mild CO intoxication, reported on the effects of exposure for varying lengths of time to an atmosphere containing 100 parts per million (ppm) of CO in a group of men between 25 and 55 years of age. These exposures produced levels of COHb ranging from 0 to 20.4%. There were strong indications that choice discrimination errors, increased reaction time, and after reactions, were increased after an exposure of 4 hours to CO and that levels of COHb, which were previously considered safe could, nevertheless, produce impairment of mental skills which can be a safety hazard, and which can also reduce greatly, efficiency and productivity.

In general, the rate of CO uptake, with corresponding effects, is related to concentrations of CO, length of exposure, partial pressure of oxygen, temperature, degree of physical activity, health status and metabolic efficiency. The presence of narcotic solvents,

TABLE I
Range-Finding Toxicity Data (Continued)

Material Studied	Single Oral LD50 for Rats ml/Kg	Single Skin Penetration LD50 for Rabbits ml/Kg	Concentrated Vapor Inhalation by Rats Maximum for No Death	Inhalation of Metered Vapor Concentration by Rats: Concentration ppm	Time, hr.	Mortality	Irritation on Uncovered Rabbit Belly	Corneal Injury in Rabbits
Amides								
N(2-Acetoxyethyl)-N-ethylacetamide	20.8 (16.8 -25.7)	>10	8 hr.	–	–	–	2	4
e-Caprolactam	2.14 (1.54 – 2.99)*	1.41	4 hr.	–	–	–	–	7
N-Ethyl-N-vinylacetamide	2.46 (1.88 – 3.23)	1.25 (0.84 - 1.85)	4 hr.	2,000	4	3/6	2	5
Propyl-N,N-diethylsuccinamate	12.93 (8.42 -19.87)	>20	8 hr.	–	–	–	4	5
Heterocyclic Compounds								
3,5-Dimethyl-1-(trichloromethylmercapto)-pyrazole	0.57 *	0.20 (0.15 - 0.27)*	4 hr.	–	–	–	6	10
Isopropylmorpholine	0.71	0.10 (0.07 - 0.15)	15 m.	500	4	5/6	6	7
Isopropylpiperazine	2.83	0.64 (0.47 - 0.86)	8 hr.	–	–	–	6	9
3,4-Lutidine	0.71 (0.40 – 1.24)	0.14	1 hr.	250†	4	0/6	6	8
N-Methyl-e-caprolactam	1.62 (1.18 – 2.24)	1.41	8 hr.	–	–	–	3	5
3-Methyl-2-oxazolidone	7.13 (3.32 -15.30)	10.8 (6.17 -16.5)	8 hr.	–	–	–	1	4
2-Methyl-5-vinylpyridine	1.30 (0.71 – 2.37)	0.80 (0.54 - 1.18)	4 hr.	4,000	8	4/6	5	8
1-(Trichloromethyl mercapto) pyrazole	0.35 *	0.063(0.047- 0.085)	–	200	1	6/6	7	9
1-(Trichloromethyl-mercapto)-4-methylpyrazole	1.04 (0.81 – 1.28)	0.079(0.059- 0.107)	2 m. §	–	–	–	7	8
Cyano Compounds								
Bis(2-isocyanatoethyl)carbonate	1.83 (1.21 – 2.79)	>12	8 hr.	–	–	–	3	9
Bis(2-isocyanatoethyl)-4-cyclohexene-1,2-dicarboxylate	10.4 (5.55 -19.4)	> 8	8 hr.	–	–	–	5	5
Bis(2-isocyanatoethyl)-5-norbornene-2,3-dicarboxylate	22.6 (13.4 -38.2)	16.1 (4.5 -57.2)	8 hr.	–	–	–	5	5
3-Butenenitrile	0.115(0.097– 0.138)*	1.41	5 m.	250†	4	0/6	2	3
N,N-Dibutyl-3-aminopropionitrile	3.25 (2.48 – 4.26)	5.04 (3.73 - 6.82)	8 hr.	–	–	–	2	2
1,6-Hexamethylene diisocyanate	0.71	0.57 (0.35 - 0.91)	8 hr.	–	–	–	8	9
Lactonitrile	0.087(0.060– 0.125)*	0.020(0.015- 0.027)	–	62.5†	4	0/6	2	–‡
3-Methoxypropionitrile	4.39 (3.07 – 5.98)*	>10	8 hr.	–	–	–	2	5
Methyl isocyanate	0.071(0.027– 0.18)*	0.22 (0.12 - 0.41)	–	31.25†	4	0/6	6	10
Tridecanitrile, mixed isomers	3.73 (2.68 – 5.21)	3.18 (1.43 - 7.06)	8 hr.	–	–	–	4	5
Halogen Compounds								
1-Bromooctane	4.49 (2.09 – 9.64)	8.00 (4.93 -13.0)	–	–	–	–	5	1
2-Chlorobutane	20.0 (12.8 -31.3)	20	5 m. §	8,000	4	3/6	1	2
Chloromethyl ether	0.21 (0.12 – 0.37)	0.28 (0.13 - 0.62)	–	8†	4	1/6	6	10
Dibromobicycloheptane, mixed isomers	0.21 (0.15 – 0.30)*	0.25 (0.19 - 0.34)	1 hr.	–	–	–	6	–
Dichlorobenzyl alcohol, mixed isomers	0.81 (0.50 – 1.31)	0.40 (0.24 - 0.65)	8 hr.	–	–	–	5	9
1,2-Dichloropropane(propylene dichloride)	1.9 (1.7 – 2.1)	8.75 (8.31 - 9.20)	10 m.	2,000	8	3/6	1	2
trans-2,3-Dichloro-1,4-dioxane	1.41	0.44 (0.27 - 0.71)	4 hr.	–	–	–	5	7
1,2-Dichloroethane(ethylene dichloride)	0.77 (0.67 – 0.89)*	3.89 (3.40 - 4.46)	–	–	–	–	2	3
Di(2-chloroethyl)acetal	0.31 (0.24 – 0.40)*	0.20 (0.14 - 0.30)	1 hr.	–	–	–	3	2
Fumaroyl chloride	0.81 (0.51 – 1.30)	1.41	–	500	4	3/6	6	10
1,1,1,3,3,3-Hexachloro-2,2-difluoropropane	0.54 (0.30 – 1.01)	4.53 (2.80 - 7.32)	–	–	–	–	3	2
m-Nitrobenzoyl chloride	2.46 (1.79 – 3.39)	0.79 (0.49 - 1.30)	8 hr.	–	–		5	9

(Continued on Next Page)

TABLE I
Range-Finding Toxicity Data (Continued)

Material Studied	Single Oral LD50 for Rats ml/Kg	Single Skin Penetration LD50 for Rabbits ml/Kg	Concentrated Vapor Inhalation by Rats Maximum for No Death	Inhalation of Metered Vapor Concentration by Rats: Concentration ppm	Time, hr.	Mortality	Irritation on Uncovered Rabbit Belly	Corneal Injury in Rabbits
Phenyl chloroformate	1.41 (0.83 – 2.40)	3.97 (2.93 - 5.37)	15 m.	44	4	3/6	6	10
Propylene chlorohydrin	0.22 (0.19 – 0.27)	0.48 (0.34 - 0.67)	15 m.	500	4	1/6	1	8
Tetrachloroethane	0.20 (0.16 – 0.27)	3.99 (3.10 - 5.13)	–	1,000	4	3/6	6	–
1,1,2,3-Tetrachloropropene	0.35 *	0.40 (0.27 - 0.59)	30 m.	250	4	5/6	5	9
1,1,2-Trichloroethane	0.58 (0.47 – 0.71)	3.73 (3.30 - 4.21)	–	500	8	4/6	2	2
Trichloroethylene	4.92 (3.75 – 6.46)	>20	–	8,000	4	4/6	5	4
Phosphorous Compounds								
Bis(2-chloroethyl)phosphite	0.26 (0.19 – 0.35)*	0.141(0.065- 0.308)	8 hr.	–	–	–	2	3
Diethyl phosphite	5.19 (2.81 – 9.58)	2.02 (1.24 - 3.29)	4 hr.	–	–	–	1	5
Trimethyl phosphate	2.83 (1.75 – 4.57)	2.83	8 hr.	–	–	–	4	2
Tris(dipropylene glycol)phosphine	19.7 (15.0 -25.8)	>10	8 hr.	–	–	–	2	1
Tris(dipropylene glycol)phosphonate	29.9 (21.4 -41.6)	15.9 (11.7 -21.5)	8 hr.	–	–	–	3	1
Sulphur Compounds								
Bis(2-acetoxyethyl)sulfone	14.1	11.3	8 hr.	–	–	–	4	2
Bis(1,2-dichloroethyl)sulfone	0.25 (0.19 – 0.32)*	1.00 (0.40 - 2.51)	8 hr.	–	–	–	7	9
2,3-Epithiopropyl methoxy ether	2.14 (1.54 – 2.99)	> 5	1 hr.	–	–	–	3	2
n-Hexyl vinyl sulfone	0.57	0.84 (0.50 - 1.40)	–	–	–	–	7	5
Isopropyl sulfate	1.09 (0.64 – 1.87)	1.41 (0.88 - 2.29)	1 hr.	–	–	–	6	5
2(Methoxyethylthio)ethanol	13.00 (7.70 -21.93)	5.04 (3.09 - 8.23)	8 hr.	–	–	–	2	5
Methylvinyloxyethyl sulfide	3.25 (2.48 – 4.26)	> 8	–	3,200	8	4/6	2	2
Tetrahydrothiophene-1,1-dioxide (sulfolane)	1.54 (1.25 – 1.91)	3.18 (2.35 - 4.29)	8 hr.	–	–	–	2	4
2,2'-Thiodiethanol diacetate	9.25 (7.51 -12.9)	>16	8 hr.	–	–	–	3	1
Trichloromethyl allyl perthioxanthate	2.18 (1.39 – 3.42)*	0.6	–	–	–	–	6	1
Trichloromethyl methyl perthioxanthate	1.54 (0.89 – 2.68)*	1.3	–	–	–	–	6	2
Silicon Compounds								
Amyl trimethoxy silane	4.92 (3.75 – 6.46)	10.00 (4.56 -21.9)	4 hr.	–	–	–	4	1
2(3,4-Epoxycyclohexyl)ethyl trimethoxy silane	12.3 (9.98 -15.3)	6.30 (4.66 - 8.52)	8 hr.	–	–	–	3	1
3(2,3-Epoxypropoxy)propyl trimethoxy silane	22.6	3.97 (2.93 - 5.37)	8 hr.	–	–	–	3	2
2-Ethylbutyl silicate	19.7 (15.0 -25.8)	>10	8 hr.	–	–	–	3	1
2-Mercaptoethyl trimethoxy silane	2.46 (1.88 – 3.23)	–	2 hr.	–	–	–	3	2
3-Mercaptopropyl trimethoxy silane	2.83 (1.61 – 4.98)	5.66	–	–	–	–	3	2
Methyl trimethoxy silane	12.5 (9.98 -15.3)	>10	1 hr.	–	–	–	3	2
Trimethoxy silane	9.33 (6.69 -13.0)	6.30 (4.66 - 8.52)	15 m.	62.5	4	5/6	3	5
Vinyl trimethoxy silane	11.3	3.54 (2.03 - 6.16)	2 hr.	4,000	4	1/6	2	1

* as gm/kg in a suitable vehicle

§ inhalation time shown killed all six rats

† twice concentration shown killed all six rats

‡ caused death when introduced into the rabbit eye

Table I
Range-Finding Toxicity Data (Continued)

Material Studied	Single Oral LD_{50} for Rats ml/Kg	Single Skin Penetration LD_{50} for Rabbits ml/Kg	Concentrated Vapor Inhalation by Rats Maximum for No Death	Inhalation of Metered Vapor Concentration by Rats: Concentration ppm	Time, hr.	Mortality	Irritation on Uncovered Rabbit Belly	Corneal Injury in Rabbits
2-Isopropoxyethanol	5.66 (4.11 – 7.79)	1.60 (1.08 - 2.37)	2 hr.	4,000	4	4/6	3	5
3-Methoxy-1-propanol	13.0 (9.90 -17.0)	5.66	8 hr.	–	–	–	1	5
2-Propoxyethanol	4.89 (4.16 - 5.73)*	0.96 (0.93 - 0.99)	–	–	–	–	2	8
Propoxypropanol, mixed isomers	3.25 (2.48 - 4.26)	4.00 (2.70 - 5.92)	8 hr.	–	–	–	2	7
Aldehydes, Ketones								
Cyclohexanone	1.62 (1.20 – 2.20)	1.00 (0.63 - 1.63)	30 m.	2,900†	4	1/6	1	5
5-Ethyl-3-nonen-2-one	8.12 (7.27 – 9.06)*	8.48 (5.04 -14.24)	8 hr.	–	–	–	2	1
Hexanal, mixed isomers	9.51 (5.84 -15.5)	>10	30 m.	–	–	–	2	5
2-Methylcyclohexanone	2.14 (1.48 - 3.10)	1.77	–	2,800	4	3/6	3	5
2-Methyl-1,2,3,6-tetrahydrobenzaldehyde	5.66	3.15 (2.33 - 4.26)	8 hr.	–	–	–	5	5
1-Tetralone	0.81 (0.62 – 1.07)	>20	8 hr.	–	–	–	4	3
Valeraldehyde	5.66	6	15 m.	4,000	4	3/6	2	5
Acids, Anhydrides, Lactones								
3-Hydroxybutyric acid lactone	17.2 (12.3 -23.9)	>20	8 hr.	–	–	–	5	5
b-Methyl-delta-valerolactone	12.9 (8.4 -19.9)	>10	–	–	–	–	1	4
Methyltetrahydrophthalic anhydride	2.14 (1.48 - 3.10)	1.41	8 hr.	–	–	–	1	9
Tri-isobutenylsuccinic anhydride	0.94 (0.61 – 1.44)*	0.89 (0.55 - 1.44)*	–	–	–	–	4	7
Valeric acid, mixed isomers	2.00 (0.90 - 4.44)	0.31 (0.06 - 1.50)	8 hr.	–	–	–	6	9
Esters, Acetals								
Acetic acid, 2-methyl-2,4-pentanediol diester	3.36 (2.06 - 5.48)	16.0 (3.33 -76.8)	8 hr.	–	–	–	3	2
Acetic acid, 2-methyl-2-propene-1,1-diol diester	0.44 (0.28 - 0.68)	0.044(0.024- 0.082)	1 hr.	62.5	4	5/6	5	9
Acetic acid, phenyl ester	1.63 (1.03 – 2.74)	8.00 (3.65 -17.5)	8 hr.	–	–	–	2	2
Acetic acid, propyl ester	9.8 (7.5 -12.9)	>20	30 m.	8,000	4	4/6	1	2
Acetic acid, triethylene glycol diester	22.6	8.0 (1.91 -33.5)	8 hr.	–	–	–	1	1
Acrylic acid, 2-butoxyethoxy ester	6.50 (4.72 - 8.95)	0.64 (0.39 - 1.04)	8 hr.	–	–	–	5	2
Acrylic acid, decyl ester, mixed isomers	12.3 (9.98 - 15.3)	3.54 (1.17 -10.7)	8 hr.	–	–	–	5	1
Acrylic acid, hexyl ester	26.0 (18.9 -35.8)	5.66 (3.50 - 9.14)	4 hr.	–	–	–	5	1
Acrylic acid, 2-hydroxypropyl ester	1.23 (0.89 – 1.70)	0.16 (0.10 - 0.26)	8 hr.	–	–	–	5	7
Acrylic acid, 2-methoxyethoxy ester	0.81 (0.59 – 1.21)	0.25 (0.17 - 0.37)	15 m.	500	4	3/6	4	5
Acrylic acid, 2-norbornyl ester	5.66	0.88 (0.54 - 1.43)	8 hr.	–	–	–	5	2
Azelic acid, dihexyl ester	16.0 (10.2 -25.0)	>20	–	–	–	–	2	1
Benzoic acid, 2-ethylhexanediol diester	29.2 (15.8 -53.9)	20	8 hr.	–	–	–	2	1
Fumaric acid, ethyl 2,3-epoxypropyl ester	1.62 (1.06 – 2.50)	0.35 (0.22 - 0.57)	–	–	–	–	5	8
Fumaric acid, dimethyl ester	2.24 (1.15 – 4.37)*	1.25 (0.84 - 1.85)*	8 hr.	–	–	–	5	9
Malonic acid, diethyl ester	14.9 (10.7 -20.8)	>16	8 hr.	–	–	–	2	5
Methacrylic acid, allyl ester	0.43 (0.31 – 0.60)*	0.50 (0.37 - 0.68)	8 m.	250†	4	0/6	5	2
Methacrylic acid, butyl ester	22.6	11.3 (5.19 -24.7)	8 hr.	–	–	–	5	1
Phthalic acid, butyl decyl ester	20.8 (16.8 -25.7)	15.9 (11.7 -21.5)	8 hr.	–	–	–	2	1
Phthalic acid, decyl hexyl ester	49.4 (39.9 -61.0)	>20	8 hr.	–	–	–	2	1

(Continued on Next Page)

Table I
Range-Finding Toxicity Data (Continued)

Material Studied	Single Oral LD_{50} for Rats ml/Kg	Single Skin Penetration LD_{50} for Rabbits ml/Kg	Concentrated Vapor Inhalation by Rats Maximum for No Death	Inhalation of Metered Vapor Concentration by Rats: Concentration ppm	Time, hr.	Mortality	Irritation on Uncovered Rabbit Belly	Corneal Injury in Rabbits
Phthalic acid, decyl octyl ester	45.2 (28.0 -73.2)	>20	8 hr.	–	–	–	2	1
Propionaldehyde dicrotyl acetal	2.14 (1.54 – 2.99)	3.54 (2.19 - 5.72)	30 m.	2,000	4	5/6	4	2
Succinic acid, di-2-[(2-ethylbutoxy)ethoxy] ester	3.3 *	7.11 (6.58 - 7.69)	–	–	–	–	3	2
Epoxy Compounds								
Bicyclononadiene diepoxide	2.14 (1.54 – 2.99)	1.77	8 hr.	–	–	–	3	5
Bis(3,4-epoxybutyl)ether	1.07 (0.77 – 1.50)	0.25 (0.17 - 0.37)	8 hr.	–	–	–	5	7
Bis(3,4-epoxy cyclohexylmethyl)adipate	4.39 (3.07 – 5.98)	>20	8 hr.	–	–	–	2	1
N,N-Bis(2,3-epoxypropyl)aniline	1.62 (1.18 – 2.24)	3.56 (1.68 - 7.57)	8 hr.	–	–	–	3	1
Butyl 2,3-epoxypropyl fumarate	0.71 (0.48 – 1.04)	1.26 (0.93 - 1.70)	8 hr.	–	–	–	5	8
t-Butylphenyl 2,3-epoxypropyl ether	3.73 (2.68 – 5.21)	5.66	8 hr.	–	–	–	5	2
1,2-Epoxy cyclohexane	1.09 (0.66 – 1.80)	0.63 (0.39 - 1.03)	30 m	2,000†	4	1/6	3	8
2,3-Epoxypropyl methacrylate	0.77 (0.57 – 1.04)	0.45 (0.21 - 0.95)	2 hr.	–	–	–	5	4
Propylene oxide	1.14 (1.05 – 1.23)	1.50 (1.07 - 21.0)	5 m. §	4,000	4	4/6	1	5
Heterocyclic Oxygen								
2-Aminomethyl-2,3-dihydro-4H-pyran	1.00 (0.64 - 1.57)*	0.18	4 hr.	–	–	–	6	9
2,5-Divinyltetrahydropyran	2.46 (1.79 – 3.39)	1.41 (0.65 - 3.08)	4 hr.	–	–	–	4	2
3,9-Divinyl-2,4,8,10-tetraoxaspiro (5.5) undecane	3.25 (2.48 – 4.26)*	7.92 (5.87 -10.73)*	8 hr.	–	–	–	2	2
2-Ethoxy-4-methyl-tetrahydropyran	5.16 (4.17 – 6.38)	> 5	4 hr.	–	–	–	2	3
Aliphatic and Alicyclic Amino Compounds								
1-Amino-3-aminomethyl-3,5,5-trimethyl cyclohexanol	1.30 (1.04 – 1.75)	–	8 hr.	–	–	–	7	9
2-Aminomethyltetrahydropyran	0.71 (0.44 – 1.13)	0.71 (0.44 - 1.14)	4 hr.	–	–	–	6	9
3-Aminopropoxy-2-ethoxy ethanol	6.50 (4.95 – 8.53)*	5.99 (4.27 - 8.42)	8 hr.	–	–	–	3	7
Amyl amine, mixed isomers	0.47 (0.33 – 0.65)*	1.12 (0.61 - 2.05)	30 m. §	2,000	4	4/6	6	9
Bis(2-dimethylaminoethoxy)ethane	2.83	1.2	–	–	–	–	7	8
Bis(2-dimethylaminoethyl) ether	1.23 (0.94 – 1.62)	0.28	8 hr.	–	–	–	6	9
Cyclohexylamine	0.71 (0.51 – 0.97)	0.32 (0.24 - 0.43)	2 hr.	4,000†	4	0/6	7	10
1,8-Diamino-p-menthane	0.77 (0.62 – 0.95)	0.63 (0.47 - 0.85)	4 hr.	–	–	–	7	9
2,4-Diamino-1-methylcyclohexane	1.41 -	0.50 (0.31 - 0.82)	8 hr.	–	–	–	6	9
Di(3-aminopropyl) ether of diethylene glycol	4.29 (3.07 – 5.98)	2.50 (1.14 - 5.48)	4 hr.	–	–	–	6	8
Di(3-aminopropoxy)ethane	2.83 (1.76 – 4.55)	1.25 (0.84 - 1.85)	8 hr.	–	–	–	6	8
N,N-Di(methyl-N-cyclohexylmethyl)amine	1.23 (0.94 – 1.62)*	0.21 (0.15 - 0.30)	8 hr.	–	–	–	7	9
N-(Methyl-N-cyclohexylmethyl)amine	1.41 *	0.63 (0.47 - 0.85)	4 hr.	–	–	–	6	9
N,N,N′,N′,N″-Pentamethyldiethylenetriamine	1.63 (1.24 – 2.13)	0.28	8 hr.	–	–	–	7	9
N,N,N′,N′-Tetramethyl-1,3-butanediamine	0.93 (0.67 – 1.30)	0.40 (0.29 - 0.54)	8 hr.	–	–	–	6	9
N,N,N′,N′-Tetramethyl-1,3-propanediamine	0.41 (0.31 – 0.53)	0.30 (0.21 - 0.42)	15 m.	1,000	4	2/6	5	9
Tetramethyl-2-tetrazene	1.78 (1.12 – 2.83)	—	4 hr.	–	–	–	2	4
Tripropylamine	0.096(0.071- 0.13)*	0.57 (0.26 - 1.23)	8 hr.	250	4	3/6	4	1
Aromatic Nitro and Amino Compounds								
3-Aminopyrene	1.07 (0.77 – 1.50)*	> 1	8 hr.	–	–	–	–	8
N-Methyl-1-naphthylamine	1.41 (1.03 – 1.95)		8 hr.	–	–	–	2	1

Range-Finding Toxicity Data: List VII

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Acute toxicity and irritation data on about 200 compounds are presented, accumulated in a continuing program for screening potential commercial products.

DURING THE SEVEN years since the appearance of our last communication on the range-finding test,[1] many additional data have become available for presentation. Table I lists these data under names conforming to the nomenclature used in *Chemical Abstracts*. Table II lists only the oral LD_{50} values for a number of inorganic compounds. All materials included are either in commercial production or have been evaluated for commercial potential within the past few years.

As has been stated in earlier communications,[1-6] the range-finding test is relied upon only to allow predictions of the comparative hazards of handling new chemicals. Acute toxicity studies, no matter how precisely executed, yield no more than an indication of the degree of care necessary to protect exposed workmen or lead to an opinion that certain technically feasible applications of a chemical may or may not eventually be proved safe.

Our last paper[1] included data under the name of triisooctyl phosphine. The compound should have been entered as triisooctyl phosphite.

Experimental methods have remained unchanged. They are described in our 1962 publication.[1]

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TABLE I
Range-Finding Toxicity Data

Material Studied	Single Oral LD_{50} for Rats ml/Kg	Single Skin Penetration LD_{50} for Rabbits ml/Kg	Concentrated Vapor Inhalation by Rats Maximum for No Death	Inhalation of Metered Vapor Concentration by Rats: Concentration ppm	Time, hr.	Mortality	Irritation on Uncovered Rabbit Belly	Corneal Injury in Rabbits
Hydrocarbons								
2-(4-Cyclohexenyl)-bicyclo-(2.2.1)-hept-5-ene	4.29 (3.07 – 5.98)	3.54 (2.19 – 5.72)	8 hr.	–	–	–	5	2
Cyclopentene	2.14 (1.45 – 3.17)	1.59 (0.97 – 2.59)	5 m. §	16,000	4	4/6	5	5
5-Ethylidene-2-norbornene	2.83	9.17 (1.35 – 6.33)	–	4,000	4	5/6	5	2
p-Menth-3-ene	20.75 (15.36 –28.03)	5.66 (2.59 –12.3)	30 m.	2,000	4	2/6	5	1
2-Norbornene	11.3 (7.0 –13.3)*	> 5	5 m.	–	–	–	1	7
1,7-Octadiene	19.7 (15.0 –25.8)	14.1 (4.66 –42.9)	15 m.	8,000	4	2/6	4	1
3a,4,7,7a-Tetrahydro-1H-indene	3.73 (2.68 – 5.21)	14.1 (8.75 –22.9)	4 hr.	–	–	–	3	2
Toluene	7.53 (6.73 – 8.43)*	14.1 (9.63 –20.77)	–	4,000	4	1/6	4	9
4-Vinyl-1-cyclohexene	3.08 (2.49 – 3.81)	20	15 m.	8,000	4	4/6	4	2
5-Vinyl-2-norbornene	5.19 (4.22 – 6.41)	15.9 (11.7 –21.5)	–	4,000	4	4/6	5	2
Hydroxyl Compounds								
p-tert. Butylphenol	3.25 (2.48 – 4.26)	2.52 (0.93 – 8.58)	8 hr.	–	–	–	6	9
Cyclohexenyl-4-phenol	2.83	3.18 (1.94 – 5.18)*	8 hr.	–	–	–	–	9
2-Cyclopenten-1-ol	0.47 (0.34 – 0.66)	0.18	1 hr.	500†	4	0/6	2	5
3,4-Dihydroxy-1,5-hexadiene	1.62 (1.24 – 2.13)	0.40 (0.29 – 0.54)	–	–	–	–	2	6
Eicosanol, mixed isomers	>64	>20	8 hr.	–	–	–	3	1
2-Ethylhexanol	2.46 (1.82 – 3.33)	2.38 (1.70 – 3.34)	8 hr.	–	–	–	3	5
Hydroxydihydrocyclopentadiene	3.25 (2.11 – 4.99)	3.15 (2.33 – 4.26)	8 hr.	–	–	–	5	9
3-Methyl-1-butanol	7.07 (4.82 –10.4)	3.97 (2.93 – 5.37)	8 hr.	–	–	–	2	8
Methyl-3-cyclohexenyl-methanol	1.41	0.62 (0.42 – 0.92)	8 hr.	–	–	–	3	8
Nonylphenol, mixed isomers	1.62 (1.06 – 2.50)	2.14 (1.52 – 2.99)	4 hr.	–	–	–	6	10
2-Norbornanemethanol	1.62 (1.24 – 2.13)*	0.80	8 hr.	–	–	–	3	9
Tetradecanol, mixed isomers	32.5 (29.1 –36.3)	7.13 (4.41 –11.52)	8 hr.	–	–	–	2	1
Ethers								
Bicyclo(2.2.1)hept-2,5-ylene bis allyl ether	3.73 (2.43 – 5.74)	5.95 (3.57 – 9.09)	8 hr.	–	–	–	3	1
2-Cyclopentyl ether	11.3	1.59 (1.03 – 2.59)	4 hr.	–	–	–	5	2
Ethyl propenyl ether	19.0 (13.4 –27.0)	>10	5 m.	8,000	4	0/6	2	2
Ethyl vinyl ether	8.16 (7.03 – 9.48)	>20	–	61,000	4	0/6	1	1
Methoxy triethylene glycol vinyl ether	11.3	10.0 (4.56 –21.9)	8 hr.	–	–	–	2	3
alpha-Methylbenzyl ether	9.80 (6.38 –15.06)*	–	8 hr.	–	–	–	4	1
2-Methoxypropene	1.87 (1.26 – 2.76)	>20	–	64,000	4	4/6	1	1
1,1,3,5-Tetramethoxyhexane	4.09 (3.52 – 4.76)*	–	8 hr.	–	–	–	2	2
Hydroxy Ethers								
1-Butoxyethoxy-2-propanol	4.00 (2.55 – 6.27)	2.83 (1.75 – 4.57)	8 hr.	–	–	–	3	5
3-Butoxy-1-propanol	5.95 (3.65 – 9.68)	1.59 (1.17 – 2.15)	8 hr.	–	–	–	2	7
Diethoxytetraethylene glycol	4.29 (2.90 – 6.34)	6.35 (3.89 –10.4)	8 hr.	–	–	–	2	2
3-Ethoxy-1-propanol	13.0 (8.46 –20.0)	2.83	8 hr.	–	–	–	2	5
2-Ethylbutoxypropanol, mixed isomers	3.56 (2.21 – 5.74)	6.0	8 hr.	–	–	–	2	9
2-Hexyloxy-2-ethoxyethyl ether	3.73 (2.68 – 5.21)	6.30 (4.66 – 8.52)	8 hr.	–	–	–	2	5
Isobutoxypropanol, mixed isomers	7.5	3.56 (1.95 – 6.52)	8 hr.	–	–	–	3	7

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